ROCKY MOUNTAIN ARSENAL

SANITARY SEWER INTERIM RESPONSE ACTION

CONSTRUCTION DOCUMENTS FOR NEW SANITARY SEWER CONSTRUCTION

VOLUME 2

Document Control Number 5300-01-03-AAAH

January 1990
Contract No. DAAA15-88-R-0023

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	01/00/90	

4. TITLE AND SUBTITLE
ROCKY MOUNTAIN ARSENAL, SANITARY SEWER, INTERIM RESPONSE ACTION, DRAFT IMPLEMENTATION PLAN

5. FUNDING NUMBERS
DAAA15 88 R 0023

6. AUTHOR(S)

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
ROY F. WESTON, INC.
LAKEWOOD, CO

8. PERFORMING ORGANIZATION REPORT NUMBER
90032R05

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
ROCKY MOUNTAIN ARSENAL (CO.). PMRMA
COMMERCE CITY, CO

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
Not a dupe of AD-A273 513

12a. DISTRIBUTION/AVAILABILITY STATEMENT
APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

THE PRIMARY OBJECTIVE OF THIS INTERIM RESPONSE ACTION IS TO PREVENT THE POTENTIAL SPREAD OF CONTAMINATION VIA THE SANITARY SEWER SYSTEM. THE IRA WILL CONSIST OF 1) CONSTRUCTION OF A NEW SANITARY SEWER AND 2) SEALING OF THE EXISTING SEWER IN THE NORTH PLANTS AND SOUTH PLANTS AREAS ALONG WITH THE INTERCEPTOR LINE IN SECTION 36.

SECTIONS OF THIS DRAFT IMPLEMENTATION DOCUMENT INCLUDE:

1. PROCEDURES FOR SEALING THE EXISTING SEWER LINES WITH CONCRETE
2. SCHEDULE OF CLOSURE EVENTS
3. DISCUSSION OF ARAR'S
4. HEALTH AND SAFETY PLAN FOR CLOSURE OF EXISTING LINES
5. SPECIFICATIONS AND PLANS FOR THE NEW SANITARY SEWER
6. HEALTH AND SAFETY PLAN FOR THE NEW SEWER PROJECT.

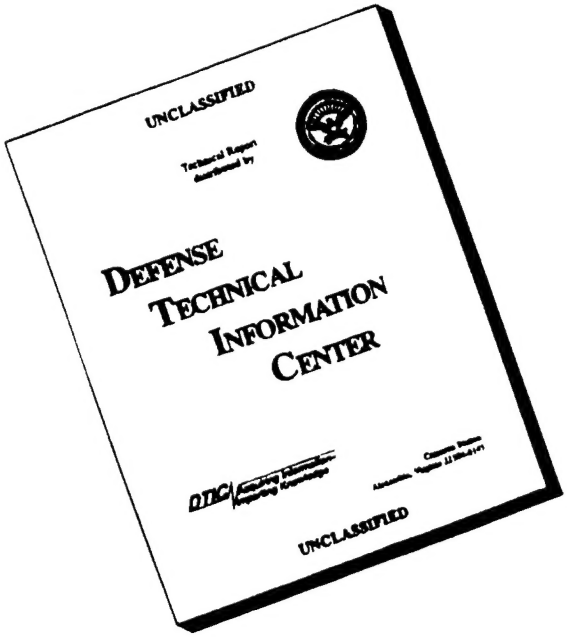
14. SUBJECT TERMS
COST, HEALTH AND SAFETY, IRA J, SOUTH PLANTS, ARARS, NORTH PLANTS, SECTION 36

15. NUMBER OF PAGES

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED			

DISCLAIMER NOTICE



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SPECIAL CLAUSES

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Submittal Register (ENG Form 4288)
Transmittal Form (ENG Form 4025)
Construction Quality Control Daily Report Form

1. **COMMENCEMENT, PROSECUTION, AND COMPLETION OF WORK.** The Contractor shall commence work under this contract within ten (10) calendar days after the date of receipt by him of Notice to Proceed, prosecute said work diligently, and complete the entire work ready for use not later than 60 calendar days after receipt of Notice to Proceed. The time stated for completion shall include final cleanup of the premises and satisfactory operation of the system.

   1.1. **START WORK.** Evidence that the Contractor has started procurement of materials, preparation and submission of shop drawings, preparation of subcontracts, and other preparatory work will satisfy the requirement that work commence within ten (10) calendar days after receipt of Notice to Proceed. Therefore, work need not be commenced at the construction site within ten (10) calendar days. (based on FAR 52.212-3)

2. **LIQUIDATED DAMAGES-CONSTRUCTION.**

2.1. **FAILURE TO COMPLY.** If the Contractor fails to complete the work within the time specified in the contract, or any extension, the Contractor shall pay to the Government as liquidated damages, the sum of _____ for each calendar day or part of calendar day of delay.

2.2. **CONTRACT TERMINATED.** If the Government terminates the Contractor's right to proceed, the resulting damage will consist of liquidated damages until such reasonable time as may be required for final completion of the work together with any increased costs occasioned the Government in completing the work.

2.3. **CONTRACT NOT TERMINATED.** If the Government does not terminate the Contractor's right to proceed, the resulting damage will consist of liquidated damages until the work is completed and accepted. (based on FAR 52.212-5)

2A. **ORDER OF WORK.**

1) Installation of force main and pumping station.

2) Installation of gravity sewer and plugging of old pipe.

3. **CONTRACT DRAWINGS AND SPECIFICATIONS.**

3.1. **SETS FURNISHED.** Eleven (11) sets of contract drawings (4 sets of full size and 7 sets of half-size) and specifications (except applicable publications incorporated into the Technical Provisions by reference) will be furnished the Contractor without charge as soon as possible after issue of the Notice To Proceed. Prior to the issue of contract drawings, bid drawings as amended shall be utilized in performance of the work. The work shall conform to the contract drawings, set out in the drawing index, all of which form a part of these specifications. The work shall also conform to the standard details bound or referenced herein.

3.2. **NOTIFICATION OF DISCREPANCIES.** The Contractor shall check all drawings furnished him immediately upon their receipt and shall promptly notify the Contracting Officer of any discrepancies. Dimensions marked on drawings shall be followed in lieu of scale measurements. Enlarged plans and details shall govern where the same work is shown at smaller scales. The Contractor shall compare all drawings and verify the figures and dimensions before laying out the work and will be responsible for any errors which might have been avoided thereby.

4. **SUBMITTALS.**

4.1. **SUBMITTAL REGISTER (ENG FORM 4288).** The Contractor will be furnished one (1) set of ENG Forms 4288 at the preconstruction conference on which will be listed each item of equipment and material of each type for which fabricators drawings, and/or related descriptive data, test reports, samples, spare parts lists, O&M manuals, or other types of submittals are required by the specifications. Columns 3, 4, 5, 6, 12, and 13 of ENG Form 4288 will be completed by the Government. A copy of the ENG Form 4288 may be obtained by written request to CEMRO-ED-DI, 215 N. 17th Street, Omaha, NE 68102-4978. The Contractor shall complete columns 7, 8, and 9 within twenty (20) calendar days after the preconstruction conference and return six (6) completed copies to the Contracting Officer's Representative for approval. Dates entered in columns

7 and 8 shall not include mail or delivery time. The ENG Forms 4288 will become a part of the contract after approval. Column 2 shall be left blank for use later to record the respective transmittal and item number indicated for the submittal items(s) listed on the transmittal form entitled: "TRANSMITTAL OF SHOP DRAWINGS, EQUIPMENT DATA, MATERIAL SAMPLES, OR MANUFACTURER'S CERTIFICATES OF COMPLIANCE" (ENG Form 4025).

4.1.1. Scheduling. Drawings on component items forming a system or that are interrelated shall be scheduled to be correlated and submitted concurrently. Certifications to be submitted with the pertinent drawings shall be so scheduled. Adequate time (a minimum of 20 calendar days exclusive of mailing time) will be allowed on the register for review and approval and possible resubmittal of any items subject to approval. No delay damages or time extensions will be allowed for time lost in late submittals or resubmittals for such items.

4.1.2. Application to Contract. The approved submittal register will become a part of the contract and Contractor will be subject to requirements thereof. This register and the progress schedules shall be coordinated.

4.2. SUBMITTAL PROCESS. The Contractor shall submit all items listed on the contract drawings and listed or specified in the other sections of these specifications. The Contracting Officer may request submittals in addition to those listed when deemed necessary to adequately describe the work covered in the respective sections. Units of weights and measures used on all submittals shall be the same used in the contract drawings. Submittals shall be made in the respective number of copies and to the respective addresses set forth below. Each submittal shall be complete and in sufficient detail for ready determination of compliance with the contract requirements. Prior to submittal, all items shall be checked and approved by the Contractor's Quality Control (CQC) Engineer and each respective transmittal form (ENG Form 4025) shall be stamped, initialed, and dated by the CQC Engineer certifying that the accompanying submittal complies with the contract requirements. Submittals shall include such items as: Contractor's, manufacturer's, or fabricator's drawings; descriptive literature including (but not limited to) catalog cuts, diagrams, operation charts or curves; test reports; test cylinders; samples, O&M manuals including parts lists; certifications; warranties and other such required submittals. Submittals pertinent to materials and equipment which are subject to advance approval shall be scheduled and made prior to the acquisition or the delivery thereof.

4.2.1. Categories of Submittals. The categories of items specified to be submitted shall be submitted as follows:

4.2.1.1. Category I. All items listed as Category I submittals in the various sections shall be mailed directly to the addressee shown below as directed. For each submittal, a completed information copy of the attached transmittal form shall also be mailed to the Area Engineer and to the Construction Division of the Omaha District.

Technical Reviewer	Abbreviations Used in Column 6 of Submittal Register
Engineering Division Attn: CEMRO-ED-DI U.S. Army Engineer District, Omaha 215 North 17th Street Omaha, NE 68102-4978	"ED"

Each required submittal which is in the form of a drawing shall be submitted as one (1) reproducible and one (1) print of the drawing. Drawing prints shall be either blue or black line permanent-type prints on a white background or blueprint. Reproducibles shall be brownline diazo or sepia and shall be of such quality that prints made therefrom are sufficiently clear for microfilm copying. All catalog and descriptive data shall be submitted in eight (8) copies. Catalog cuts and other descriptive data which have more than one model, size, or type or which shows optional equipment shall be clearly marked to show the model, size, or type and all optional equipment which is proposed for approval. Submittals on component items forming a system or that are interrelated shall be submitted at one time as a single submittal in order to demonstrate that the items have been properly coordinated and will function as a unit.

4.2.1.2. **Category II.** Except as noted below, data for all items listed as Category II Submittals in the various sections shall be submitted in five (5) copies to the Area Engineer using the transmittal form. Items not to be submitted in quintuplicate, such as samples and test cylinders, shall be submitted to the Area Engineer accompanied by five (5) copies of the transmittal form.

4.2.2. **Control of Submittals.** The Contractor shall carefully control his procurement operations to assure that each individual submittal is made on or before the corresponding date scheduled on his approved "SUBMITTAL REGISTER."

4.2.3. **Transmittal Form (ENG Form 4025).** The sample transmittal form attached to this section shall be used for submitting both the Category I and Category II submittals, in strict accordance with the instructions on the reverse side thereof. These forms will be furnished to the Contractor. This form shall be properly completed by filling out all the heading blank spaces and identifying each item submitted. Special care should be exercised to ensure proper listing of the specification paragraph and/or sheet number of the contract drawings pertinent to the data submitted for each item. A separate transmittal form shall be attached to each copy of the data being submitted.

4.2.4. **Approval Action.**

4.2.4.1. **Category I.** All Category I submittals are subject to advance approval. Upon completion of review of Category I submittals, the drawing reproducible and print and other pertinent data will be identified as having received approval by being so stamped and dated. The drawing print and six (6) sets of all catalog data and descriptive literature will be retained by the Contracting Officer and the drawing reproducible and two (2) sets of catalog data and descriptive literature will be returned to the Contractor.

4.2.4.2. **Category II.** Submittals may be required for "Approval" or for "Information Only." Within the terms of the CONTRACT CLAUSES clause entitled "Specifications and Drawings for Construction," Category II submittals "for approval" are considered to be "shop drawings" and

Category II submittals "for information only" are not considered to be "shop drawings." Two (2) copies of Category II submittals for approval will be returned to the Contractor except for samples, test cylinders, and O&M manuals for which two (2) copies of the transmittal form only will be returned to the Contractor. Submittals for "Information Only" will not be returned to the Contractor. No Corps of Engineers' approval action will be required prior to incorporating these "Information Only" items into the work. These Contractor approved "Information Only" submittals will be used to verify that material received and used in the job is the same as that described in the plans and specifications and will be used as record copies. Delegation of this approval authority to the CQC Engineer does not relieve the Contractor from the obligation to furnish material conforming to the plans and specifications and will not prevent the Contracting Officer from requiring removal and replacement if nonconforming material is incorporated in the work. This obligation does not relieve the Contractor from the requirement to furnish samples for testing by the Government laboratory or check testing by the Government in those instances where the technical specifications so prescribe.

4.2.5. **Meaning of Approvals.** The approval of the submittals by the Contracting Officer or his authorized representative shall not be construed as a complete check, but will indicate only that the general method of construction and detailing is satisfactory. Approval will not relieve the Contractor of the responsibility for any error which may exist as the Contractor, under the CQC requirements of this contract, is responsible for the dimensions and design of adequate connections, details and satisfactory construction of all work. After submittals have been approved by the Contracting Officer or his authorized representative, no resubmittal for the purpose of substituting materials or equipment will be given consideration unless accompanied by an acceptable explanation as to why a substitution is necessary.

4.2.6. **When Not Approved.** The Contractor shall make all corrections required by the Contracting Officer or his authorized representative and promptly furnish a corrected submittal in the form and number of copies as specified for initial submittals. If the Contractor considers any correction indicated on the submittals to constitute a change to the contract, notice as required under the CONTRACT CLAUSES clause entitled "Changes" should promptly be given to the Contracting Officer.

4.2.7. **Withholding of Payment.** Payment for materials incorporated into the work will not be made if required approvals have not been obtained.

4.3. **CERTIFICATES OF COMPLIANCE.** Any certificates required for demonstrating proof of compliance of materials with specification requirements shall be executed in three copies. Each certificate shall be signed by an official authorized to certify in behalf of the manufacturing company and shall contain the name and address of the Contractor, the project name and location, and the quantity and date or dates of shipment or delivery to which the certificates apply. Copies of laboratory test reports submitted with certificates shall contain the name and address of the testing laboratory and the date or dates of the tests to which the report applies. Certification shall not be construed as relieving the Contractor from furnishing satisfactory material, if, after tests are performed on selected samples, the material is found not to meet the specific requirements. (EFARS 52.2/9108(c))

4.4. **PURCHASE ORDERS.** Each purchase order issued by the Contractor or his subcontractors for materials and equipment to be incorporated into the project shall (1) be clearly identified with the applicable DA contract number, (2) carry an identifying number, (3) be in sufficient detail to identify the material being purchased, (4) indicate a definite delivery date, and (5) display the DMS priority rating. Copies of purchase orders shall be furnished to the Contracting Officer when requested by the Contracting Officer for the purpose of quality assurance review.

4.5 **OPERATION AND MAINTENANCE INSTRUCTIONS AND/OR MANUALS.** Where required by various technical sections, operations and maintenance instructions and/or manuals with parts lists included shall be provided by the Contractor in quintuplicate, unless otherwise specified, and shall be assembled in book form having a cover indicating the contents by equipment or system name and project title and shall be submitted for approval to the Contracting Officer 30 days prior to final tests of mechanical and electrical systems. Each operation and maintenance manual shall contain a copy of all warranties and a list of local service representatives required by SECTION: WARRANTY OF CONSTRUCTION. If field testing requires these copies to be revised, they shall be updated and resubmitted for approval within 10 calendar days after completion of tests. The Operations and Maintenance Instructions and/or Manuals shall be shown as a separate activity on the Contractor prepared construction schedule bar chart or network analysis system.

5. **PHYSICAL DATA.** Pursuant to CONTRACT CLAUSES clause: "Site Investigation and Conditions Affecting the Work," information and data furnished or referred to below are furnished for general information only and the Government may not be held liable for any interpretation or conclusions drawn therefrom by the Contractor.

5.1. **SOURCE OF DATA.** The physical conditions indicated on the drawings and in the specifications are the result of site.

5.2. **WEATHER.** Weather conditions shall have been investigated by the Contractor to satisfy himself as to the hazards likely to arise therefrom. Complete weather records and reports may be obtained from the local U.S. Weather Bureau.

5.3. **ACCESS ROUTES.** Transportation facilities shall have been investigated by the Contractor to satisfy himself as to the existence of access highways and railroad facilities. (based on FAR 52.236-4)

5.4. **CONCURRENT CONSTRUCTION.** Construction work closely related to and/or located at the site of the work under this contract, including Interim Response Actions will be in progress simultaneously with work under this contract. The location of this concurrent work is in various areas around the Base. The Contractor shall cooperate with others as necessary in the interest of timely completion of all work. In the event of interference, the Contracting Officer shall be notified immediately for resolution and his decision shall be final. All road crossings shall be maintained and shall be passable at all times. Short, temporary detours shall be coordinated with the base commander and the Fire Department.

5.5. **TELEPHONE SERVICE.** Telephone and radio service for Contractor facilities shall will be the Contractor's responsibility.

6. **PAYMENT.**

6.1. **PROMPT PAYMENT ACT.** Pay requests authorized in CONTRACT CLAUSES clause: "Payments Under Fixed-Price Construction Contracts", will be paid pursuant to the clause, "Prompt Payment for Construction Contracts". Pay

requests will be submitted on ENG Form 93 and 93a, "Payment Estimate-Contract Performance" and "Continuation". All information and substantiation required by the identified contract clauses will be submitted with the ENG Form 93, and the required certification will be included on the last page of the ENG Form 93a, signed by an authorized contractor official and dated when signed. The designated billing office is the Office of the Area Engineer.

6.2. **PAYMENTS FOR MODIFICATIONS.** Payments may be made for cost bearing change orders within the scope of the contract only to the extent funds are authorized in the order on a two-part modification. Contractor pricing proposed must be submitted at the earliest possible time after the change order is issued, or at a specific time as directed by the Contracting Officer. At the discretion of the Contracting Officer, any and all payments may be withheld on the modification until the Contractor has submitted a qualifying price proposal, in as much detail as required by the Contracting Officer, and the final price has been agreed.

6.3. **PAYMENT FOR MATERIALS DELIVERED OFFSITE.** No payment will be made for materials that are not on site and intended for exclusive use on this project.

7. **AVAILABILITY OF UTILITY SERVICES.** Water and electricity are not readily available at this site. It will be the contractor's responsibility to provide for the utilities that may be required for the successful completion of this project. Water is available on base at the Fire Department, but the Contractor shall be responsible for transporting, storing, and coordinating dispensing with the Fire Department.

8. **UTILITY SERVICE INTERRUPTIONS.** The Contractor shall not disrupt base utilities as partial this project. The contractor shall cause all utilities in the vicinity of this project to be located and marked. Contractor shall protect marked utilities during the duration of this project.

8.1. **OVERTIME WORK BY BASE OPERATING AND MAINTENANCE (O&M) PERSONNEL.** The normal working hours for Government O&M personnel whose services may be required for utility outages or similar services are from 7:30 a.m. to 4:00 p.m. Overtime work by Government O&M personnel due to Contractor delays in scheduled outages, interruptions of known utility services, or other negligent acts, shall be the responsibility of the Contractor. The Contractor shall pay the Government for such additional overtime costs at the existing overtime wage rates established for the Government personnel involved.

8.2. **BURIED UTILITIES.** The Contractor shall coordinate all excavation work including excavation for sign posts, fence posts, and utility poles with the Using Service Facilities Engineer and the telephone company prior to beginning work.

8A. **DIGGING PERMITS AND ROAD CLOSINGS.** The Contractor shall allow 14 calendar days from date of written application to receive permission to dig and to close roads. Roads shall only be closed one lane at a time and vehicular traffic shall be allowed to pass through the construction area. Work on or near roadways shall be flagged in accordance with the safety requirements in Safety and Health Requirements Manual EM 385-1-1, which forms a part of these specifications. Work located along the alert force route shall not cause blockage and the Contractor shall maintain unobstructed access for alert force traffic at all times.

9. **LAYOUT OF WORK.** The Contractor shall lay out his work from Government established bench marks indicated on the drawings and shall make all measurements in connection therewith. The Contractor shall furnish all stakes, templates, platforms,

equipment, tools, and materials and labor as may be required in laying out any part of the work from the base lines and marks established by the Government. The Contractor shall execute the work to the lines and grades established or indicated and shall maintain and preserve all stakes and other control points established by the Contracting Officer until authorized to remove them. If such marks are destroyed by or through negligence of the Contractor, prior to their authorized removal, they may be replaced by the Contracting Officer at his discretion and the expense of replacement will be deducted from any amounts due or to become due the Contractor. (based on FAR 52.236-17)

10. **QUANTITY SURVEYS.**

10.1. The Contractor shall make such surveys and computations as are necessary to determine the quantities of work performed or placed during each period for which a progress payment is to be made. The Contractor shall also make original and final surveys. The Government will make such computations as are necessary to verify the quantities of work performed or finally in place. Unless waived by the Contracting Officer in each specific case, quantity surveys made by the Contractor shall be made under the direction of a representative of the Contracting Officer.

10.2. All original field notes, computations, and other records of the Contractor for the purposes of layout, original, progress, and final surveys shall be recorded in duplicating field books, the original pages of which shall be furnished promptly in ring binders to the representative of the Contracting Officer at the site of the work and shall be used by the Contracting Officer to the extent necessary in determining the proper amounts of progress and final payments. (based on FAR 52.236-16)

10A. **VARIATIONS IN ESTIMATED QUANTITIES.** Significant variations from the contract unit priced quantities shall be covered in accordance with the CONTRACT CLAUSES clause: "Variation in Estimated Quantity."

11. **TIME EXTENSIONS FOR UNUSUALLY SEVERE WEATHER.**

11.1. **ANTICIPATED WEATHER DELAYS.** Time extensions requested for adverse weather delays shall be based upon weather conditions that affect normal working days and are unexpected on unusually severe for the time of year at the site. Delay claims must be made in writing to the contract offices within 24 hours of the claimed weather occurrence. ONly 5 weather delay days will be allowed during the term of this project. Claims for weather delay shall be for extension of the contract time only. Cost claims for extended overhead, etc. will not be allowed.

11.2. **THE CONTRACTOR'S SCHEDULE** must reflect the above anticipated adverse weather delays on all weather dependent activities.

12. **INSURANCE REQUIRED.** In accordance with CONTRACT CLAUSES clause: "Insurance Work on a Government Installation," the Contractor shall procure the following minimum insurance:

Type	Amount
Workmen's Compensation and Employer's Liability Insurance	$100,000
General Liability Insurance	$500,000 per occurrence
Automobile Liability Insurance Bodily injury	$200,000 per person and $500,000 per occurrence
Property damage	$ 20,000 per occurrence

(Coverages per FAR 28.307-2)

13. **IDENTIFICATION OF EMPLOYEES.** The Contractor shall furnish to each employee and require each employee engaged on the work to display, such identification as may be approved and directed by the Contracting Officer. All prescribed identification shall immediately be delivered to the Contracting Officer, for cancellation upon release of any employees. When the contract involves work in restricted security areas, only employees who are U.S. citizens will be permitted to enter. Proof of U.S. citizenship is required prior to entry. When required by the Contracting Officer, the Contractor shall obtain and submit fingerprints of all persons employed or to be employed on the project. (based on FAR 52.236-7007)

14A. **VEHICLE IDENTIFICATION.** All privately owned vehicles including Contractor pickups, but not heavy equipment or trailer towed equipment shall be registered while working on post. Contractor personnel shall register their vehicles at the M.P. Vehicle Registration Trailer any work day between the hours of 0700-1115 and 1300 to 1600. A safety inspection will be required and each vehicle owner will need to show (1) a valid driver's license, (2) a current vehicle registration, and (3) proof of automobile liability insurance.

15. **CONTRACTOR QUALITY CONTROL (CQC).** In conformance with the requirements of CONTRACT CLAUSES clause: "Inspection of Construction," the Contractor shall establish and maintain an effective Quality Control Program.

15.1. **GENERAL.** Except for isolated tests or other items of work specified to be performed by the Government, the quality of all work shall be the responsibility of the Contractor. Sufficient inspections and tests of all items of work, including that of subcontractors, to ensure conformance to applicable specifications and drawings with respect to the quality of materials, workmanship, construction, finish, functional performance, and identification shall be performed on a continuing basis. The Contractor shall furnish qualified personnel, appropriate facilities, instruments and testing devices necessary for the performance of the quality control function. The controls shall be adequate to cover all construction operations both on and offsite, shall be keyed to the proposed construction sequence and shall be correlated by the Contractor's quality control personnel.

15.2. **PRECONSTRUCTION PLANNING.** The Government will consider an interim CQC plan for the first days of operation. However, within ten (10) calendar days after the date of receipt by him of Notice to Proceed, and prior to starting on-site construction, the Contractor shall meet with the Contracting Officer and discuss the quality control requirements. During this meeting the Contractor shall submit for approval his proposed written QC plan which shall include all features outlined below. The proposed plan will be reviewed and the meeting shall develop mutual understanding relative to details of the system, including the personnel, facilities, forms, etc., to be used for the inspections, tests and the

administration of the system. Minutes of the meeting shall be prepared by the Area Office Resident Engineer or Contractor as agreed to at the mutual understanding meeting and shall be signed by both the Contractor and the Contracting Officer or Contracting Officer's Representative. The minutes shall become a part of the contract. No change in the approved plan shall be implemented without written concurrence by the Contracting Officer.

15.3. **ACCEPTANCE OF CQC PLAN.** Acceptance of the Contractor's quality control plan is required prior to the start of construction. Acceptance is conditional and will be predicated on satisfactory performance during the construction. The Government reserves the right to require the Contractor to make changes in his CQC plan and operations as necessary to obtain the quality specified.

15.4. **CONTRACTOR'S PROPOSED (QC) PLAN.** The Contractor's proposed written quality control plan (for submittal at the mutual understanding meeting) shall include as a minimum:

15.4.1. The quality control organization.

15.4.2. Names, number, and qualification of personnel to be used for this purpose.

15.4.3. Authority and responsibilities of all quality control personnel.

15.4.4. Schedule of Use of inspection personnel by types and phase of work.

15.4.5. A list of preparatory and initial inspections to be performed shall be included as part of the Quality Control Program.

15.4.6. A list of tests specified to be performed with proposed test methods including specification paragraph number and names of technicians or qualified testing laboratory to be used.

15.4.7. Location and availability of test facilities and equipment.

15.4.8. Procedures for advance notice and coordination of special inspections and tests where required.

15.4.9. Procedures for reviewing all shop drawings, samples, certificates, or other submittals for contract compliance and certifying them for submission to the Government.

15.4.10. Method of performing, documenting, and enforcing quality control operations of both prime and subcontract work including inspection and testing both onsite and offsite. Include proposed forms for approval, and indicate who will prepare, sign, and submit the reports.

15.4.11. Responsibilities and procedures for correcting deficiencies.

15.4.12. A copy of a letter of direction to the Contractor's representative responsible for quality control, outlining his duties and responsibilities, and signed by a responsible officer of the firm.

15.4.13. Method of documenting and tracking deficiencies and corrective actions.

15.5. **CONTROL OF ON-SITE CONSTRUCTION.** The Contractor's quality control program shall include four phases of inspection and tests. The Contracting Officer's representative shall be notified at least 24 hours in advance of each such test.

15.5.1. Preparatory Inspections shall be performed prior to beginning each feature of work on any on-site construction work. Preparatory inspections for the applicable feature of work shall include (i) review of submittal requirements and all other contract requirements with the foremen or supervisors directly responsible for the performance of the work; (ii) check to assure that provisions have been made to provide required field control testing; (iii) examine the work area to ascertain that all preliminary work has been completed; (iiii) verify all field dimensions and advise the Contracting Officer of any discrepancies; and (iiiii) perform a physical examination of materials and equipment to assure that they conform to approved shop drawings or submittal data and that all materials and/or equipment are on hand.

15.5.2. Initial Inspection shall be performed as soon as work begins on a representative portion of the particular feature of work and shall include examination of the quality of workmanship as well as a review of control testing for compliance with contract requirements.

15.5.3. Follow-up Inspections shall be performed continuously as any particular feature of work progresses, to assure compliance with contract requirements including control testing, until completion of that feature of the work.

15.5.4. Safety Inspections. The Contractor shall perform daily safety inspections of the jobsite and the work in progress to assure compliance with EM 385-1-1 and other occupational health and safety requirements of the contract. Daily Quality Control reports as required under paragraph: REPORTING shall be used to document the inspection and shall include a notation of the safety deficiencies observed and the corrective actions taken. The Contractor shall use his designated Quality Control Staff to perform the required inspections and shall supplement the staff with additional personnel as required. Additional personnel shall be provided at no additional cost to the Government.

15.5.5. Recording Inspection Results. The results of all inspections shall be made a matter of record in the Contractor's Quality Control documentation as required by paragraph DOCUMENTATION below.

15.6. **QUALITY CONTROL STAFF.** In addition to the Contractor's job supervisory staff, a separate quality control group shall be provided. This group shall report to the Contractor's management at a level no lower than an executive of the company. As a minimum, the overall strength of the quality control group for this contract shall be as follows:

15.6.1. The Quality Control Supervisory Engineer shall be an approved, qualified engineer or technician whose sole responsibility is to ensure compliance with the contract plans and specifications. This person shall demonstrate ability to perform correctly the duties required to the satisfaction of the Contracting Officer and shall be physically at the project site whenever work is in progress and will be in charge of the Contractor's Quality Control program for this project. All the Contractor's submittals for approval shall be reviewed and modified or corrected as needed by the Quality Control Supervisory Engineer (or authorized assistants) and approved correct prior to forwarding of such submittals to the Contracting Officer.

15.6.2 A Mechanical Technician, who is experienced in the construction of industrial air-conditioning, steam and sewer systems, plumbing, heating, mechanical tests, and other components of mechanical devices equipment and/or systems in the work, shall assist in performance of the QC Supervisory Engineer's duties. The Mechanical Technician may have other duties but shall be on the project site at the times indicated in both the approved QC Plan and Progress Chart.

15.6.3. An Electrical Technician, experienced in the construction of industrial electrical systems, overhead and underground high voltage systems, instrumentation and control systems, and the required electrical tests shall assist in performance of the QC Supervisory Engineer's duties. The Electrical Technician may have other duties but shall be on the project site at the times indicated in both the approved QC Plan and Progress Charts.

15.6.4. A Certified Industrial Hygienist and an Industrial Hygiene Technician shall assist in the performance of the QC Supervisory Engineer's duties.

15.7. TESTS.

15.7.1. **Testing Procedure.** The Contractor shall perform tests specified or required to verify that control measures are adequate to provide a product which conforms to contract requirements. The Contractor shall procure the services of an industry recognized testing laboratory approved by the Contracting Officer, or may establish an approved testing laboratory at the project site. The Contractor shall perform the following activities and record and provide the following data:

15.7.1.1. Verify that testing procedures comply with contract requirements.

15.7.1.2. Verify that facilities and testing equipment are available and comply with testing standards.

15.7.1.3. Check test instrument calibration data against certified standards.

15.7.1.4. Verify that recording forms, including all of the test documentation requirements, have been prepared.

15.7.2. **Testing.**

15.7.2.1. **Capability Check.** The Contracting Officer's Representative (COR) will have the right to check laboratory equipment in the proposed laboratory for compliance with the standards set forth in the contract specifications and to check the laboratory technician's testing procedures and techniques.

15.7.2.2. **Capability Re-Check.** If the selected laboratory fails the capability check, the Contractor will be assessed the actual cost for the re-check as reimbursement to the Government for each succeeding re-check of the laboratory or the checking of a subsequently-selected laboratory.

Such costs will be deducted from the contract amount due the Contractor.

15.7.2.3. **Project Laboratory.** The COR will have the right to utilize the Contractor's control testing laboratory and equipment to make assurance tests and to check the Contractor's testing procedures, techniques, and test results at no additional cost to the Government.

15.8. **REPORTING.** All inspections and test results shall be recorded daily.

15.8.1. **Daily Submittals.** The attached sample "Quality Control Daily Report" form or other approved form shall be reproduced and fully executed to show all inspections and tests and submitted in duplicate to the Contracting Officer's representative on the first work day following the date covered by the report.

15.8.2. **Results of Tests.** Triplicate copies of complete results of tests shall be submitted not later than 3 calendar days after performing the test.

15.9. **COMPLETION INSPECTIONS.**

15.9.1. **Contractor's Quality Control Completion Inspection.** Based upon the Contracting Officer's concurrence that the work is nearing substantial completion, and at least 14 days prior to pre-final inspection, the Contractor's Quality Control Inspection personnel shall conduct a detailed inspection. The Contracting Officer's Representative shall be notified of the inspection date in order that he may participate, if he so elects. The work shall be inspected for conformance to plans, specifications, quality, workmanship, and completeness. The Contractor shall prepare an itemized list of work not properly completed, inferior workmanship, or not conforming to plans and specifications. The list shall also include outstanding administrative items such as as-built drawings, O&M Manuals, and spare parts. The list shall be included in the Quality Control documentation and submitted to the Contracting Officer with an estimated date for correction of each deficiency within five (5) working days after conducting this inspection.

15.9.2. **Pre-Final Inspection.** The Contractor's Quality Control Inspection personnel, his superintendent, or other primary management person and the Contracting Officer's representatives will be in attendance at this inspection. Additional Government personnel, including but not limited to those from Base/Post Civil/Facility Engineer, user groups and major commands may be in attendance. The prefinal inspection will be formally scheduled by the Contracting Officer based upon notice from the Contractor. This notice will be given to the Contracting Officer at least 14 days prior to the pre-final inspection and must include the Contractor's assurance that all specific items previously identified to the Contractor as being unacceptable, along with all remaining contract work, will be complete and acceptable by the date scheduled for the prefinal inspection. Failure of the Contractor to have all contract work acceptably complete for this inspection will be cause for the Contracting Officer to bill the Contractor for the Government's additional inspection costs in accordance with the contract clause entitled, "Inspection of Construction." At this inspection the Contracting Officer will develop a specific list of incomplete and/or unacceptable work performed under the

contract and will subsequently furnish this list to the Contractor. Failure of the Contracting Officer to detect and list all incomplete and/or unacceptable work during this inspection will not relieve the Contractor from acceptably performing all work required by the contract documents.

15.9.3. **Final Acceptance Inspection.** The Contractor's Quality Control Inspection personnel, his superintendent or other primary management person and the Contracting Officer's representative will be in attendance at this inspection. Additional Government personnel including, but not limited to, those from Base/Post Civil/Facility Engineer, user groups, and major commands may also be in attendance. The final acceptance inspection will be formally scheduled by the Contracting Officer based upon notice from the Contractor. This notice will be given to the Contracting Officer at least 14 days prior to the final acceptance inspection and must include the Contractor's assurance that all specific items previously identified to the Contractor as being unacceptable, along with all remaining work performed under the contract will be complete and acceptable by the date scheduled for the final acceptance inspection. Failure of the Contractor to have all contract work acceptably complete for this inspection will be cause for the Contracting Officer to bill the Contractor for the Government's additional inspection costs in accordance with the contract clause entitled "Inspection of Construction".

15.10. DOCUMENTATION.

15.10.1. The Contractor shall maintain current records of quality control operations, activities, and tests performed including the work of suppliers and subcontractors. These records shall be on an acceptable form and indicate a description of trades working on the project, the number of personnel working, the weather conditions encountered, any delays encountered, and acknowledgment of deficiencies noted along with the corrective actions taken on current and previous deficiencies. These records shall include factual evidence that required activities or tests have been performed, including but not limited to the following:

15.10.1.1. Type, number, and results of control activities and tests involved.

15.10.1.2. Nature of defects and causes of rejection.

15.10.1.3. Proposed remedial action.

15.10.1.4. Corrective actions taken.

15.10.2. These records shall cover both conforming and defective or deficient features and shall include a statement that supplies and materials incorporated in the work comply with the contract. Legible copies of these records shall be furnished to the COR daily.

15.11. ENFORCEMENT. The Contractor shall stop work on any item or feature, pending satisfactory correction of any deficiency noted by his quality control staff or by the Contracting Officer's representative. Construction shall not proceed upon any feature of work containing uncorrected work. Notations on quality control reports will not be acceptable as a substitution for other written reports by the Contractor if required under CONTRACT CLAUSES clause: "Changes," "Differing Site Conditions," or "Default (Fixed-Price Construction)."

15.12. **NOTIFICATION OF NONCOMPLIANCE.** The Contracting Officer will notify the Contractor of any noncompliance with the foregoing requirements. The Contractor shall, after receipt of such notice, immediately take corrective action. Such notice, when delivered to the Contractor or his representative at the site of the work, shall be deemed sufficient for the purpose of notification. If the Contractor fails or refuses to comply promptly, the Contracting Officer may issue an order stopping all or part of the work until satisfactory corrective action has been taken. No part of the time lost due to any such stop orders shall be made the subject of claim for extension of time or for excess costs or damages by the Contractor.

15.13. **PAYMENT.** At the election of the Contracting Officer, no payment estimate will be processed under this contract until the entire Quality Control Plan has been approved or until overdue daily QC reports are properly executed and furnished.

16. **NONDOMESTIC CONSTRUCTION MATERIALS.** The requirements of this contract entitled Buy American Act Construction Materials do not apply to construction materials or their components included in the list set forth in paragraph 25.108 of the Federal Acquisition Regulation.

17. **DAILY WORK SCHEDULES.** In order to closely coordinate work under this contract, the Contractor shall prepare for and attend a weekly coordination meeting with the Contracting Officer and Using Service at which time the Contractor shall submit for coordination and approval, his proposed daily work schedule for the next two week period. Required temporary utility services, and protection of adjoining areas shall be included with the Contractor's proposed 2-week work schedule. Coordination action by the Contracting Officer relative to these schedules will be accomplished during these weekly meetings.

18. **AS-BUILT DRAWINGS.** The Contractor shall maintain two separate sets of red-lined full scale, as-built construction drawings marked-up to fully indicate as-built conditions. These drawings shall be maintained in a current condition at all times until completion of the work and shall be available for review by Government personnel at all times. The location, general description, approximate depth below finished grade of all underground utilities encountered, and all variations from the contract drawings, for whatever reason, including those occasioned by optional materials and the required coordination between trades, shall be indicated. These variations shall be shown in the same general detail utilized in the initial contract drawings. Both sets of as-built construction drawings shall be furnished to the Contracting Officer on the date of final inspection. The submittal requirement for as-built construction drawings shall be shown as a separate activity on the Contractor prepared progress bar chart or network analysis system, whichever is applicable.

19. **SUPERINTENDENCE OF SUBCONTRACTORS.**

19.1. **ADDED SUPERINTENDENTS.** The Contractor shall furnish the following, in addition to the superintendence required by the CONTRACT CLAUSES clause entitled "Superintendence by the Contractor."

19.1.1. If more than 50 percent and less than 70 percent of the value of the contract work is subcontracted, one superintendent shall be provided at the site and on the Contractor's payroll to be responsible for coordinating, directing, inspecting and expediting the subcontract work.

19.1.2. If 70 percent or more of the value of the work is subcontracted, the Contractor shall be required to furnish two such superintendents to be responsible for coordinating, directing, inspecting and expediting the subcontract work.

19.2 **WAIVER OF ADDED SUPERINTENDENTS.** If the Contracting Officer, at any time after 50 percent of the subcontracted work has been completed, finds that satisfactory progress is being made, he may waive all or part of the above requirement for additional superintendence subject to the right of the Contracting Officer to reinstate such requirement if at any time during the progress of the remaining work he finds that satisfactory progress is not being made. (based on FAR 52.236-7008)

20. **TIME EXTENSIONS.** Notwithstanding any other provisions of this contract, the time extensions for changes in the work will depend upon the extent, if any, by which the changes cause delay in the completion of the various elements of construction. The change order granting the time extension may provide that the contract completion date will be extended only for those specific elements so delayed and that the remaining contract completion dates for all other portions of the work will not be altered and may further provide for an equitable readjustment of liquidated damages pursuant to the new completion schedule. (based on FAR 52.212-6)

21. **OPERATIONS AND MAINTENANCE DATA AND TRAINING REQUIREMENTS.**

21.1. The Operations and Maintenance Data required by this paragraph is in addition to Operations and Maintenance Instructions and/or Manuals required in paragraph: OPERATIONS AND MAINTENANCE INSTRUCTIONS AND/OR MANUALS above. The Operations and Maintenance Data required by this paragraph shall be shown as a separate activity on the construction schedule bar chart or network analysis system.

21.2. Operations and Maintenance Data shall consist of one (1) corrected copy of all Categories I and II submittals including one (1) updated copy of all Operations and Maintenance Instructions and/or Manuals. The Operations and Maintenance Data shall be checked for completeness, indexed, packaged, and shall be submitted to the Contracting Officer at time of contract completion and shall be addressed to: Engineering Division CEMRO-ED-DI U.S. Army Engineer District, Omaha, 215 North 17th Street, 1612 U.S. Post Office and Courthouse, Omaha, NE 68102-4978.

21.3. **TRAINING.** The Contractor shall provide training for base personnel on the systems and system's components listed below. Where a minimum number of training hours are not specified, the instruction period shall be of sufficient length to explain the operation, maintenance, repair, and checkout procedures of the system. Where training required by technical sections of these specifications is longer than the training required below, the longer training period shall be used. Following training and initial system startup and testing, the Contractor shall supervise Base personnel in performing system startup and testing. Base personnel will follow the Contractor's operation instructions provided.

a. Hoists and Trolleys.
b. Pumps and controls (min 2M).
c. Plumbing, Backflow Preventive Devices (Testing and Maintenance).
e. Alarm Testing Procedures (Fire Protection).
g. Exterior Electrical.
   (1) Operating and Troubleshooting (2 hrs).
   (2) Maintenance (Min 2 hrs).

h. Interior Electrical.
   (1) Startup Procedures (Motor Control Center) (Min 2 hrs).
   (2) Maintenance of Controllers including Electric Watt/Demand Meter (Min 2 hrs).

i. Cathodic Protection, Review of Manual.

22. **APPLICABILITY OF DAVIS-BACON ACT.** It is the position of the Department of Defense that the Davis-Bacon Act, 40 U.S.C. 276a is applicable to temporary facilities such as batch plants, sandpits, rock quarries, and similar operations, located off the immediate site of the construction but set up exclusively to furnish required materials for a construction project on the site of the work. Clause "Payrolls and Basic Records" of the CONTRACT CLAUSES is applicable to such operations.

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SECTION 01200
WARRANTY OF CONSTRUCTION

INDEX

1. WARRANTY OF CONSTRUCTION (APR 1984).

1.1. In addition to any other warranties in this contract, the Contractor warrants, except as provided in paragraph 1.10 below, that work performed under this contract conforms to the contract requirements and is free of any defect in equipment, material, or design furnished, or workmanship performed by the Contractor or any subcontractor or supplier at any tier.

1.2. This warranty shall continue for a period of 1 year from the date of final acceptance of the work. If the Government takes possession of any part of the work before final acceptance, this warranty shall continue for a period of 1 year from the date the Government takes possession.

1.3. The Contractor shall remedy at the Contractor's expense any failure to conform, or any defect. In addition, the Contractor shall remedy at the Contractor's expense any damage to Government-owned or controlled real or personal property, when that damage is the result of:

1.3.1. The Contractor's failure to conform to contract requirements; or

1.3.2. Any defect of equipment, material, workmanship, or design furnished.

1.4. The Contractor shall restore any work damaged in fulfilling the terms and conditions of this clause. The Contractor's warranty with respect to work repaired or replaced will run for 1 year from the date of repair or replacement.

1.5. The Contracting Officer shall notify the Contractor, in writing, within a reasonable time after the discovery of any failure, defect, or damage.

1.5.1. If the Contractor fails to remedy any failure, defect, or damage within a time as specified in paragraph: WARRANTY SERVICE CALLS after receipt of notice, the Government shall have the right to replace, repair, or otherwise remedy the failure, defect, or damage at the Contractor's expense.

1.6. With respect to all warranties, express or implied, from subcontractors, manufacturers, or suppliers for work performed and materials furnished under this contract, the Contractor shall:

1.6.1. Obtain all warranties that would be given in normal commercial practice;

1.6.2. Require all warranties to be executed, in writing, for the benefit of the Government and

1.6.3. Enforce all warranties for the benefit of the Government, if directed by the Contracting Officer.

1.7. In the event the Contractor's warranty under paragraph 1.2 above has expired, the Government may bring suit at its expense to enforce a subcontractor's, manufacturer's, or supplier's warranty.

1.8. Unless a defect is caused by the negligence of the Contractor or subcontractor or supplier at any tier, the Contractor shall not be liable for the repair of any defects of material or design furnished by the Government nor for the repair of any damage that results from any defect in Government furnished material or design.

1.9. This warranty shall not limit the Government's rights under the Inspection and Acceptance clause of this contract with respect to latent defects, gross mistakes, or fraud.

1.10. Defects in design or manufacture of equipment specified by the Government on a "brand name and model" basis, shall not be included in this warranty. In this event, the Contractor shall require any subcontractors, manufacturers, or suppliers thereof to execute their warranties, in writing, directly to the Government. (Based on FAR 52.246-21)

2. **WARRANTY SERVICE CALLS.** The Contractor shall furnish to the Contracting Officer the names of local service representatives and/or Contractors that are available for warranty service calls and who will respond to a call within the time periods as follows: 4 hours for heating, air-conditioning, refrigeration, air supply and distribution, and critical electrical service systems and food service equipment, and 24 hours for all other systems. The names, addresses, and telephone numbers for day, night, weekend, and holiday service responses shall be furnished to the Contracting Officer and also posted at a conspicuous location in each mechanical and electrical room or close to the unit.

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SECTION 01400
SPECIAL SAFETY REQUIREMENTS

INDEX

1. **GENERAL.** This section provides additional requirements for implementing the accident prevention articles in CONTRACT CLAUSES clause: "Accident Prevention" and Safety and Health Requirements Manual EM 385-1-1.

2. **PRECONSTRUCTION CONFERENCE.** A preconstruction conference will be scheduled prior to beginning of site work at which time representatives of the Contracting Officer will review and discuss requirements relative to planning and administration of the overall safety program.

3. **ACCIDENT PREVENTION PROPOSAL.** The Contractor has the option to submit his own accident prevention proposal or utilize the basic safety program as outlined in subparagraphs 3.1 through 3.11. In the event the Contractor submits his own proposal, as a minimum it will incorporate or cover the basic points as outlined in subparagraphs 3.1 through 3.11 and the site health and safety plans from the implementation document.

   3.1. **RESPONSIBLE INDIVIDUAL.** The Contractor shall designate an approved onsite employee as the individual responsible for insuring the accident prevention proposal is implemented, enforced, and that inspections of scaffolding, mechanical equipment and hand tools are made as required.

   3.2. **INDOCTRINATION OF EMPLOYEE BEFORE START OF WORK.** The Contractor shall indoctrinate each employee to insure the following items are covered:

      (a) Purpose of the accident prevention program (i.e., to minimize the hazards and reduce injuries).

      (b) Review of representative hazards on the job and the precautions to be taken.

      (c) Location of first aid and other emergency facilities and what to do in case of injury, fire or when a serious hazard is noted.

      (d) Time and location of Tool Box Safety Meetings.

      (e) Required protective equipment such as goggles, respirators, lifelines, and hard hats.

      (f) Brief review of clean-up procedure.

      (g) Location of company safety rules (posting or handout).

3.3. **TOOL BOX SAFETY MEETINGS.** Hold weekly Tool Box Safety Meetings for all contractor employees. Timely safety subjects shall be determined by a responsible individual. Submit written notice to the Contracting Officer.

3.4. **FIRE PROTECTION AND PREVENTION.** Insure adequate fire extinguishers, water barrels, or other fire-fighting equipment is located onsite. Extinguishers shall be on hand wherever welding or cutting is being accomplished, with the use of flammables and other special hazards.

3.5. **HOUSEKEEPING.** Daily clean-up of all debris and waste materials is required. Adequate disposal containers should be placed strategically around the site. Debris shall be removed on a regular basis.

3.6. **MECHANICAL EQUIPMENT INSPECTION.** All mechanical equipment (trucks, cranes, forklifts, backhoes, graders, etc.) shall be inspected prior to its use and at fixed intervals throughout the life of the contract.

3.7. **FIRST AID AND MEDICAL.** First aid facilities shall be made available on the job site. Arrangements for emergency medical attention shall be made prior to start of work. All emergency numbers (doctor, hospital, ambulance, fire department) shall be posted at the project superintendent's office.

3.8. **SANITATION FACILITIES.** Sufficient numbers of toilet facilities as specified in para. 03.B of EM 385-1-1 shall be provided unless permission is granted to use existing facilities. Portable chemical are authorized. Insure safe drinking water and individual cups are available. For the projects where corrosive or toxic materials are used, separate washing facilities are required.

3.9. **SAFETY PROMOTION.** The Contractor shall promote accident prevention by use of one or more of the following: posters, display materials, safety contests, awards programs and similar items.

3.10. **ACCIDENT REPORTING.** All accidents (employee injuries, vehicle, building, or equipment property damage), regardless of their severity, shall be reported to the onsite Government Representative or to the Area Engineer. The Contractor will be notified of the forms to be submitted.

3.11. **PHASE SAFETY PLANNING.** Before each phase of work begins, a phase plan listing the possible hazards that might be expected while accomplishing that phase of work and the procedures to be used to overcome or eliminate the hazards of that phase will be discussed between the Contractor and the onsite Government Representative. A phase is defined as an operation involving a type of work which presents hazards not experienced in previous operations or where new subcontractors are performing the work (i.e., earth moving, trenching, concrete work, roofing, electrical, masonry). The onsite Government Representative will determine the format and amount of detail required of the written plan. The amount of detail will be determined by the complexity of that phase of work.

4. **RADIOLOGICAL EQUIPMENT.** In accordance with Requirement 08.F.01 of EM 385-1-1, entitled Safety and Health Requirement Manual, the Contractor is required to obtain a service permit to use, store, operate, or handle a radiation producing machine or radioactive materials on a Department of Defense (DOD) Installation. The service permit shall be obtained from the appropriate U.S. Army or U.S. Air Force Command through the Contracting Officer's representative. The Contractor should notify the Contracting Officer during the prework conference if a radiation producing device will be utilized on a DOD Installation in order to determine the permit application requirements, and allow a lead time of 45 days for obtaining a permit.

5. SPECIAL SAFETY REQUIREMENTS OF POST, BASE, OR PLANT.

6. CONTRACTOR SAFETY PERSONNEL REQUIREMENTS (1985 JAN HQ USACE).

6.1. **GENERAL.** The Contractor shall employ at the project site, to cover all hours of work, at least one Safety and Occupational Health (SOH) person to manage the Contractor's accident prevention program. Duties which are not germane to the safety program shall not be assigned to the SOH person(s). The principal safety person shall report to and work directly for the Contractor's onsite top manager, higher level official, or corporate safety office. The SOH person(s) shall have the authority to take immediate steps to correct unsafe or unhealthful conditions. The presence of a SOH person will not abrogate safety responsibilities of other personnel. The Contractor shall submit names and qualifications of the nominated SOH person(s) to the Contracting Officer for acceptability and a functional description of duties shall be provided prior to the preconstruction conference.

6.2. **QUALIFICATIONS FOR SOH PERSON(S).** The Contractor's SOH person(s) shall be required to have one of the following experience and/or education qualifications:

6.2.1. A degree in engineering or safety in at least a 4-year program from an accredited school; or

6.2.2. A legal registration as a professional engineer or a certified safety person and, in addition, shall have been engaged in safety and occupational health for at least one (1) year of experience, of which no less than fifty (50) percent of the time was devoted to safety and occupational health; or

6.2.3. A degree other than that specified above and, in addition, shall have been engaged in safety and occupational health for at least three (3) years of which no less than fifty (50) percent of the time each year was devoted to safety and occupational health; or

6.2.4. Qualified experience in safety and occupational health for at least five (5) years of which no less than fifty (50) percent of the time each year was devoted to safety and occupational health.

6.2.5. In any of the above, first aid work shall not be considered as creditable experience (based on EFARS 52.2/9303).

INTERIM CHANGE TO EM 385-1-1 - SAFETY AND HEALTH REQUIREMENTS MANUAL

1. Page 21, Section 07.A.03, replace with the following:

"07.A.03 - Protective footwear, such as rubber boots, protective covers, ice clamp-ons, and steel-toed safety boots, shall be worn by all persons exposed to hazards to the feet (including, but not limited to impact, puncture, slipping, electrical, or chemical hazards).

a. For all activities in which Corps or contractor personnel or official visitors are potentially exposed to foot hazards, the applicable job/activity hazard analysis, accident prevention plan, or project safety plan shall include an analysis of, and prescribe specific protective measures to be enforced for, foot hazards.

b. Footwear providing protection against impact and compressive forces, conduction hazards, electrical hazards, and sole puncture shall meet the applicable requirements of ANSI Z41."

2. Page 143, Section 18.C.05, replace with the following:

"18.C.05 - All load drums on loading-hoisting equipment shall be equipped with at least one positive holding device. This device should be applied directly to the motor shaft or some part of the gear train. It is not necessary that the positive holding device utilize shearing of metal to meet this requirement. Friction surfaces are acceptable."

3. Page 145, add Sections 18.C.24 and 18.C.25 which will read:

"18.C.24 - During personnel handling operations load and boom hoist drum brakes, swing brakes, and locking devices such as pawls or dogs shall be engaged when the occupied platform is in a stationary working position.

"18.C.25 - During personnel handling operations the load hoist drum shall have a system or device on the power train other than the load hoist brake, which regulates the lowering rate of speed of the hoist mechanism (controlled load lowering). Free fall is prohibited."

4. Page 146, Section 18.D.09, replace with the following:

"18.D.09 - All telescopic boom cranes engaged in standard lift operations (including concrete bucket) should be equipped with a two-block warning feature(s), a two-block damage prevention feature, or an anti-two block device for all points of two-blocking (i.e., jibs, extension, etc). In addition, all new telescopic boom cranes shall be equipped with an anti-two block device or a two-block damage prevention feature for all points of two-blocking. Cranes that are used exclusively as duty cycle machines (clamshell, dragline, grapple, pile driving operations) are exempt from this requirement but will meet the requirements of ANSI/ASME-B30.5-1982 (as revised). To alleviate difficulties associated with attaining compliance, an implementation time period until 1 January 1991 is granted. In all cases where cranes are utilized without these safeguards equivalent protection shall be established, documented and approved by the designated authority."

5. Page 146, add Sections 18.D.10 and 18.D.11, which will read:

"18.D.10 - All lattice boom cranes engaged in standard lift crane operations (including concrete bucket) shall be equipped with a two-block warning feature which functions for all points of two-blocking. Cranes that are used exclusively as duty cycle machines (clamshell, dragline, grapple, pile driving operations) are exempt from this requirement but will meet the requirements of ANSI/ASME-B30.5-1982 (as revised). To alleviate difficulties associated with attaining compliance, an implementation time period until 1 January 1991 is granted. In all cases where cranes are utilized without these safeguards equivalent protection shall be established and documented and then approved by the designated authority."

"18.D.11 - During personnel handling operations all telescopic and lattice boom cranes shall be equipped with a device which when activated disengages all functions whose movement can cause contact between the load block or overhaul ball and the boom tip (anti-two block device), or a system shall be used which deactivates the hoisting action before damage occurs in the event of a two-blocking situation (two-block damage prevention feature). The device or system must be installed for all points of two-blocking (i.e. jib or boom points) and in the case of the anti-two block device the crane must be equipped with automatic brakes on each hoist line; hoist lines not so equipped must be taken out of service while personnel lifts are being made."

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SECTION 02221
EXCAVATION, TRENCHING, AND BACKFILLING
FOR UTILITIES SYSTEMS

INDEX

PART 1 - GENERAL

1. **APPLICABLE PUBLICATIONS.** The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

1.1. **AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) PUBLICATIONS.**

D 1556-82	Density of Soil In Place by the Sand-Cone Method
D 1557-78	Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 10-lb (4.54 kg) Rammer and 18-inch (457 mm) Drop
D 2487-85	Classification of Soils for Engineering Purposes
D 2922-81	Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
D 3017-78	Moisture Content of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
E 548-84	Preparation of Criteria for Use in Evaluation of Testing Laboratories and Inspection Bodies

2. **DEFINITIONS.**

2.1. **SUITABLE MATERIALS.** Suitable materials shall consist of any material not included in the unsuitable materials definition.

2.2. **UNSUITABLE MATERIALS.** Unsuitable materials include but are not limited to those materials containing roots and other organic matter, trash, debris, frozen materials and stones larger than 3 inches, and materials classified in ASTM D 2487 as MH, PT, OH, and OL. Unsuitable materials also include landfills, refuse, contaminated soil, or debris from previous construction as determined by the Contracting Officer, otherwise suitable material which is unsuitable due to excess moisture content will not be classified as unsuitable material unless it cannot be dried by manipulation, aeration, or blending with other materials.

2.3. **COHESIONLESS AND COHESIVE MATERIALS.** Cohesionless materials shall include materials classified in ASTM D 2487 as GW, GP, SW, and SP. Cohesive materials include materials classified as GC, SC, ML, CL, MH, and CH. Materials classified as GM and SM will be identified as cohesionless only when the fines are nonplastic.

2.4. **SELECT GRANULAR MATERIAL.** Select granular material shall consist of well-graded sand, gravel, crushed gravel, crushed stone or crushed slag composed of hard, tough and durable particles, and shall not contain more than 10 percent

by weight of material passing a No. 200 mesh sieve and no less than 95 percent by weight passing the 1-inch sieve, with a maximum allowable aggregate size of 1 inch or the maximum size recommended by the pipe manufacturer, whichever is smaller, unless otherwise specified.

2.5. **DEGREE OF COMPACTION.** Degree of compaction shall be expressed as a percentage of the maximum density obtained by the test procedure presented in ASTM D 1557.

PART 2 - EXECUTION

3. **EXCAVATION.** Excavation of every description and of whatever substances encountered shall be performed to the lines and grades indicated. During excavation, material suitable for backfilling shall be stockpiled in an orderly manner at a distance from the banks of the trench sufficient to avoid overloading and to prevent slides or cave-ins. Adequate drainage shall be provided for the stockpiles and surrounding areas by means of ditches, dikes, or other approved methods. The stockpiles shall also be protected from contamination with unsuitable excavated material or other material that may destroy the quality and fitness of the suitable stockpiled material. If the Contractor fails to protect the stockpiles and any material becomes unsatisfactory as a result, such material, if directed, shall be removed and replaced with satisfactory on-site or imported material from approved sources at no additional cost to the Government. Excavated material not required or not satisfactory for backfill shall be disposed of in waste areas as directed by the Contract Officer. Grading shall be done as may be necessary to prevent surface water from flowing into the excavation, and any water accumulating therein shall be removed so that the stability of the bottom and sides of the excavation is maintained. Unauthorized overexcavation shall be backfilled in accordance with paragraph BACKFILLING at no additional cost to the Government.

3.1. **TRENCH EXCAVATION.** The trench below the top of the pipe shall not be excavated wider than the outside diameter of the pipe plus 24 inches for pipes of less than 24 inch inside diameter and no wider than the outside diameter of the pipe plus 36 inches for larger sizes. Where trench widths are exceeded, redesign using stronger pipe or special installation procedures shall be necessary. Cost of this redesign and increased cost of pipe or installation shall be borne by the Contractor without additional cost to the Government. Trench walls below the top of the pipe shall be vertical. Trench walls above the top of pipe may be sloped or widened as necessary for the proper safe performance of the work.

3.1.1. **Bottom Preparation.** Trench bottoms shall be over excavated to allow the installation of granular bedding as detailed on the drawings.

3.1.2. **Removal of Unsuitable Material.** Where unsuitable material is encountered in the bottom of the trench, such material shall be removed to the depth directed and replaced to the proper grade with select granular material as provided in paragraph BACKFILLING. When removal of unstable material is required due to the fault or neglect of the Contractor in his performance of work, the resulting material shall be excavated and replaced by the Contractor without additional cost to the Government.

3.1.3. **Special Excavation in Contaminated Soils.**

3.1.3.1. **Excavation for pipeline** must cross an identified chemical waste line as identified on plans. 10' on each side of crossing shall be performed as indicated in 3.1.4.2. Should contaminated soils be encountered, all personnel on site will be required to have 40 hours Health and Safety training.

3.1.3.2. **Excavation in contaminated soil area** shall be performed as follows:

1. Excavate soil, using machinery, one bucket at a time.
2. Analyze each bucket with an OVA monitor and an H-Nu and determine if soil is contaminated. Any reading on either instrument above background on 3 consecutive buckets will be considered contaminated.
3. If soil is contaminated, dispose soil in drums provided by government. Replace and compact with select or sand fill material as directed in Backfill.
4. If soil is not contaminated, stockpile spoil and use for backfill.
5. At end of each shift decontaminate equipment as required and drum waste for disposal by government. Refer to the site Health an Safety plan for personnel protection requirements.
6. Base bids shall include the cost of monitoring in the potentially contaminated zone but shall assume clean excavation materials. Provide total cost addition per cubic yard of excavated soil, including additional material required for backfilling, should contaminated soils be encountered in the schedule of values.

3.2. **EXCAVATION FOR APPURTENANCES.** Excavation for manholes or similar structures shall be of sufficient size to permit the placement and removal of forms for the full length and width of structure footings and foundations as shown and to allow the placement of any required precast concrete element and pipe fittings. Removal of unsuitable material shall be as specified above. When concrete or masonry is to be placed in an excavated area, special care shall be taken not to disturb the bottom of the excavation. Excavation to the final grade level shall not be made until just before the concrete or masonry is to be placed.

3.3. **DEWATERING.** The Contractor shall provide and maintain adequate dewatering equipment to remove and dispose of all surface and ground water entering excavations, trenches, or other parts of the work. Each excavation shall be kept dry during subgrade preparation and continually thereafter until the structure to be built, or the pipe to be installed, therein is completed to the extent that no damage from hydrostatic pressure, flotation, or other cause will result. All excavations for concrete structures or trenches which extend down to or below ground water shall be dewatered by lowering and keeping the ground water level beneath such excavations 12 inches or more below the bottom of the excavation. Surface water shall be diverted or otherwise prevented from entering excavated areas or trenches. Existing drainage facilities may be used for disposal of surface and ground water during dewatering operations subject to prior approval of the Contracting Officer. The Contractor shall be responsible for all damages incurred to the drainage facilities as a result of the dewatering operations. All pipes or conduits shall be left clean and free of sediment.

3.4. **SHEETING AND SHORING.** Except where banks are cut back on a stable slope, excavation for structures and trenches shall be sheeted, braced, and shored, as necessary, to prevent caving or sliding, to provide protection for workmen and the work, and to provide protection for existing structures and facilities. Sheeting, bracing, and shoring shall be designed and built to withstand all loads that might be caused by earth movement or pressure, and shall be rigid, maintaining shape and position under all circumstances.

4. **BACKFILLING.** Backfill material shall consist of suitable material. Backfill shall be placed in layers not exceeding 8 inches loose thickness for compaction by hand operated machine compactors. Each layer shall be compacted to at least 95 percent maximum density obtained as measured by the Standard Proctor Density.

4.1. **TRENCH BACKFILL.** Trenches shall be backfilled to the grade shown. The trench shall be backfilled to 2 feet above the top of pipe prior to performing the required pressure test. The joints and couplings shall be left uncovered during the pressure test.

4.1.1. **Not Used.**

4.1.2. **Replacement of Unsuitable Material.** Unsuitable material removed from the bottom of the trench or excavation shall be replaced with select granular material placed in layers not exceeding 6 inches loose thickness.

4.1.3. **Bedding.** Bedding shall conform to the details shown on the drawings and specified below. Material shall be deposited in 8 inch loose layers and compacted with approved methods to at least 95 percent maximum density. Care shall be taken to ensure thorough compaction of the fill under the pipe haunches. Bedding shall consist of select granular material.

4.1.3.1. **Class A Bedding.** Class A bedding is not required unless improper trenching or unexpected trench conditions require its use.

4.1.3.2. **Class B Bedding.** Class B bedding shall be used for all gravity sewer lines.

4.1.3.3. **Class C Bedding.** Class C bedding shall be used for all pressure pipe. A maximum allowable aggregate size of 1/2 inch shall be used for all plastic pressure pipe, ductile, or cast iron pipe.

4.1.4. **Initial Backfill** shall consist of suitable materials with a maximum stone size not exceeding the limits shown on the drawings. Initial backfill shall be placed in 6-inch loose thickness layers and compacted to at least 90 percent of maximum density at moisture contents that will facilitate compaction in granular materials and shall be within -1 and +4 percent of optimum for all other materials. Initial backfill shall be placed to a height of at least 1 foot above the top of the pipe. Care shall be taken to ensure thorough compaction of the fill under the haunches of the pipe.

4.1.5. **Final Backfill.** The remainder of the trench, except for special materials for roadways, railroads and airfields, shall be backfilled with suitable material. Backfill material shall be deposited and compacted as follows:

4.1.5.1. **Roadways, Railroads, and Airfields.** Backfill shall be placed up to the elevation of the base course in 8-inch layers and compacted to 98 percent maximum density. Base course shall be compacted to 98 percent maximum density. Pavement shall conform to PARAGRAPH: PAVEMENT AND WALK REMOVAL AND REPLACEMENT. Water flooding or jetting methods of compaction will not be permitted.

4.1.6. **Miscellaneous Areas.** Backfill shall be deposited in layers of a maximum of 12-inch loose thickness, and compacted to 85 percent maximum density for cohesive soils and 90 percent maximum density for cohesionless soils. Compaction by water flooding or jetting will not be permitted. This requirement shall also apply to all other areas not specifically designated above.

4.2. **BACKFILL FOR APPURTENANCES.** After the manhole or similar structure has been constructed backfill shall be placed in such a manner that the structure will not be damaged by the shock of falling earth. The backfill material shall be deposited and compacted as specified for final backfill, and shall be placed in such a manner as to prevent eccentric loading and excessive stress on the structure.

5. **SPECIAL REQUIREMENTS.** Special requirements for both excavation and backfill relating to the specific utilities are as follows:

5.1. **WATER AND SEWER LINES.** Trenches shall be of a depth to provide a minimum cover of 5 feet from the existing ground surface, or from the indicated finished grade, whichever is lower, to the top of the pipe.

5.2. **PLASTIC MARKING TAPE.** Warning tape shall be of the type specifically manufactured for marking and locating underground utilities. The tape shall be installed directly above the pipe, at a depth of 24 inches below finished grade unless otherwise shown. The tape shall be acid and alkali-resistant polyethylene film, 6 inches wide with minimum thickness of 0.004 inch and shall have a minimum strength of 1750 psi lengthwise and 1500 psi crosswise with an elongation factor of 350 percent. Tape color shall be as specified in Table 1 and shall bear a continuous printed inscription describing the specific utility.

Table 1. Tape Color

Red:	Electric
Green:	Sewer Systems

Tape for all nonmetallic utility lines shall have integral wires, foil backing, or other means to enable detection by a metal detector when the tape is buried up to 3 feet deep. The metallic core shall be encased in a protective jacket or provided with other means to protect it from corrosion.

6. **TESTING.** Testing shall be the responsibility of the Contractor and shall be performed at no additional cost to the Government.

6.1. **DETERMINATION OF DENSITY.** Density tests shall be performed by an approved commercial testing laboratory or may be tested by facilities furnished by the Contractor. Approval of testing facilities shall be based on compliance with ASTM E 548, and no work requiring testing will be permitted until the facilities have been inspected and approved by the Contracting Officer. Tests shall be performed in sufficient numbers to ensure that the specified density is being obtained for each lift. One test shall be made for each 3000 square yards or less for each layer of specified depth, except areas to receive pavements, for which one test shall be made for each 1000 square yards or less. Laboratory tests for moisture-density relations shall be determined in accordance with ASTM D 1557, Method B, C, or D. A mechanical tamper may be used, provided the results are correlated with those obtained by the referenced hand tamper. Field in-place density shall be determined in accordance with ASTM D 1556, ASTM D 2167, or ASTM D 2922. When ASTM D 2922 is used, the

calibration curves shall be checked and adjusted using only the sand cone method as described in paragraph "Calibration" of ASTM D 2922. ASTM D 2922 results in a wet unit weight of soil and when using this method, ASTM D 3017 shall be used to determine the moisture content of the soil. The calibration curves furnished with the moisture gages shall be checked along with density calibration checks as described in ASTM D 3017. The calibration checks of both the density and moisture gages shall be made at the beginning of a job, on each different type of material encountered, at intervals as directed by the Contracting Officer. If ASTM D 2922 is used for field density control, there should be at least one test performed according to ASTM D 1556 per every ten tests performed according to ASTM D 2922 for correlation of test results. Copies of calibration curves and results of calibration tests shall be furnished to the Contracting Officer within 24 hours of conclusion of the tests. Trenches improperly compacted shall be reopened to the depth directed, then refilled and compacted to the density specified at no additional cost to the Government. Documentation of compaction testing shall be delivered to the Contracting Officer prior to processing with next project phase.

6.2. **DISPLACEMENT OF SEWERS.** After other required tests have been performed and the trench backfill compacted to 3 feet above the top of the pipe, the pipe shall be inspected to determine whether significant displacement has occurred. This inspection shall be conducted in the presence of the Contracting Officer. Pipe sizes larger than 36 inches shall be entered and examined, while smaller diameter pipe shall be inspected by shining a light or laser between manholes or manhole locations, or by use of television cameras passed through the pipe. If, in the judgment of the Contracting Officer, the interior of the pipe shows poor alignment or any other defects that would cause improper functioning of the system, the defects shall be remedied as directed at no additional cost to the Government.

7. PAVEMENT AND WALK REMOVAL AND REPLACEMENT.

7.1. **FLEXIBLE PAVEMENT.** Where construction requires cutting and replacing of flexible pavement, cutting shall be so accomplished that the remaining exposed edges shall conform vertically and horizontally to a straight line. The full depth of surface and binder course shall be removed to a width of 10 feet with a saw cut on the edges. Base course shall be removed to a point 1 foot back from each side of the trench. The replaced pavement shall match the existing in section and depth and shall conform to SECTION: BITUMINOUS INTERMEDIATE AND SURFACE COURSES, and SECTION: SUBBASE COURSE. Concrete curb and gutter shall be removed to the nearest joint. Saw cutting to a minimum depth of 1 inch will be permitted if the remaining section to the next joint is 4 feet or more. Replaced section shall match the adjacent curb and gutter and shall be 4000 psi concrete, air-entrained. Waste materials shall be disposed of off-Base.

ZERO ACCIDENTS

SECTION 02234
SUBBASE COURSE

INDEX

1. **APPLICABLE PUBLICATIONS.** The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

1.1. **AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) PUBLICATIONS.**

C 88-83	Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate (CRD-C 137-77)
C 117-84	Materials Finer than 75 um (No. 200) Sieve in Mineral Aggregates by Washing
C 131-81	Resistance to Degradation of Small Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
C 136-84a	Sieve Analysis of Fine and Coarse Aggregates
D 75-87	Sampling Aggregates
D 422-63 (R 1972)	Particle-Size Analysis of Soils
D 1556-82	Density of Soil in Place by the Sand-Cone Method
D 1557-78	Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 10-lb Rammer and 18-in Drop
D 2922-81	Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
D 3017-78	Moisture Content of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
D 4318-84	Liquid Limit, Plastic Limit, and Plasticity Index of Soils
E 11-81	Wire-Cloth Sieves for Testing Purposes

2. **DEFINITION.** The degree of compaction required is expressed as a percentage of the maximum density obtained by the test procedure presented in ASTM D 1557, Method D or AASHTO T 180, Method D. This will be abbreviated herein as percent Laboratory maximum density.

3. **EQUIPMENT.** All plant, equipment, and tools used in the performance of the work will be subject to approval before the work is started and shall be maintained in satisfactory working condition at all times. The equipment shall be adequate and shall

have the capability of producing the required compaction, meeting grade controls, thickness control, and smoothness requirements as set forth herein.

4. **APPROVAL, SAMPLING AND TESTING.** Sampling and testing shall be the responsibility of the Contractor and shall be performed at no additional cost to the Government. Sampling and testing shall be performed by commercial testing laboratory. Tests shall be performed at the frequency specified hereinafter. Copies of the production test results shall be reported in the Contractor's Daily Quality Control Reports as soon as the tests are performed and in every case prior to placing subsequent construction over the subbase course.

4.1. **GENERAL.** The Contractor shall select the source of materials and perform the initial sampling and testing sufficiently in advance to not delay the work. The Contractor shall control his operations during production and placement of material, so that the materials in the completed course will meet the specified requirements. The Government may perform verification tests for final approval of the materials in the completed course. All quality control sampling and testing shall be performed by the Contractor in accordance with paragraph: CONTRACTOR QUALITY CONTROL in SECTION: SPECIAL CLAUSES and as specified herein.

4.2. **SAMPLES.** All samples shall be taken in conformance with ASTM D 75 unless otherwise approved or directed.

4.3. **TESTS.** The following tests shall be performed by the Contractor.

4.3.1. **Aggregate Gradation.** Aggregate gradation shall be determined in accordance with ASTM C 117, C 136, and D 422. Sieves shall conform to ASTM E 11.

4.3.2. **Wear (L.A. Abrasion) Test** shall be made in conformance with ASTM C 131.

4.3.3. **Liquid-Limit and Plasticity-Index** shall be determined in accordance with ASTM D 4318.

4.3.4. **Moisture-Density Determinations.** The maximum density and optimum moisture shall be determined in accordance with ASTM D 1557, Method D.

4.3.5. **Soundness** shall be determined in accordance with ASTM Standard C 88, using magnesium sulfate.

4.3.5. **Field Density Tests.** Density shall be measured in the field in accordance with ASTM D 1556, or ASTM D 2922. For the method presented in ASTM D 1556, the base plate as shown in the drawing shall be used. Tests performed in accordance with ASTM D 2922 result in a wet unit weight of soil and when using this method, ASTM D 3017 shall be used to determine the moisture content of the soil. The calibration curves furnished with the moisture gages shall also be checked along with density calibration checks as described in ASTM D 3017. Calibration curves for the moisture gages specified in ASTM D 3017 and for density gages as specified in ASTM D 2922 shall be furnished. The calibration curves for the moisture gages and density gages shall be checked at the beginning of the job and on each type of material encountered on the job. If nuclear devices are used, not less than 1 of every 10 consecutive field density tests shall be in accordance with ASTM D 1556 to provide correlation. Calibration test results and correlation tests shall be furnished within 24 hours of the conclusion of the tests. At least one

field density test shall be performed for each 1,000 square yards of each layer of base material.

4.4. **TESTING FREQUENCY.**

4.4.1. **Initial Tests.** One of each of the following tests shall be performed on the proposed material prior to commencing construction to demonstrate that the proposed material will meet all specified requirements when furnished and after placing and compaction.
Sieve Analysis including 0.02 mm size material
Liquid-Limit and Plasticity-Index
Moisture-Density Relationship

5. **SUBMITTALS.** In accordance with SECTION: SPECIAL CLAUSES, the Contractor shall submit the following:

5.1. **CATEGORY I.** None

5.2. **CATEGORY II.** (For information only)
Initial test results on the proposed materials (Para. 4.4.1)

6. **WEATHER LIMITATIONS.** Subbase courses shall be constructed when the atmospheric temperature is above 35 degrees F. When the temperature falls below 35 degrees F., the Contractor shall protect all areas of completed subbase course by approved methods against detrimental effects of freezing. Areas of completed subbase course damaged by freezing, rainfall, or other weather conditions shall be corrected to meet specified requirements.

7. **MATERIALS.** Aggregates shall consist of crushed stone, gravel, crushed gravel, sand and gravel, manufactured sand, or other sound, durable, approved materials, processed and blended. Disintegrated granite shall not be used for production of any aggregate and the processed aggregate shall contain not more than 2.0 percent by weight of disintegrated granite particles in that portion of the total sample larger than the No. 4 sieve and not more than 4.0 percent in any individual sieve size listed in the required aggregate gradation for that portion larger than the No. 4 sieve. A disintegrated granite particle is defined as a soft, crumbly particle of igneous rock having a visible crystalline grain size and consisting essentially of feldspar and quartz with lesser amounts of micas and/or amphiboles and pyroxenes. Generally, the rock particle will be stained by iron oxide and the feldspar grains will have a dull, highly fractured appearance. The individual mineral grains are so weakly bonded that the particle will crumble under moderate pressure. When tested by CRD-C 130 the particle would be classified as soft. Aggregates shall be durable and sound, free from lumps and balls of clay, organic matter, objectionable coatings, and other foreign material. Material retained on the No. 4 sieve shall have a percentage of wear not to exceed 50 percent after 500 revolutions when tested as specified in ASTM C 131; and shall have a loss in weight not to exceed 18 percent when subjected to 5 cycles of the soundness test as specified in subparagraph: Soundness. Aggregate shall be reasonably uniform in density and quality, and free from thin and elongated pieces. The maximum size of aggregate shall be not over 2 inches and the material shall be well graded within the limits specified as follows as determined from samples of the compacted and completed course.

Sieve designation	Maximum allowable percentage by weight passing square-mesh sieve
No. 10	0 - 50
No. 200	0 - 8
0.02 mm	0 - 3

The portion of any blended component and of the completed course passing the No. 40 sieve shall be either nonplastic or shall have a liquid limit not greater than 25 and a plasticity index not greater than 5.

8. **STOCKPILING MATERIAL.** Prior to stockpiling of material, storage sites shall be cleared and leveled by the Contractor. All materials, including approved material available from excavation and grading, shall be stockpiled in the manner and at the locations designated. Aggregates shall be stockpiled on the cleared and leveled areas designated by the Contracting Officer so as to prevent segregation. Materials obtained from different sources shall be stockpiled separately.

9. **PREPARATION OF SUBGRADE.** Prior to constructing the subbase course, the previously constructed subgrade shall be cleaned of all foreign substances. Ruts or soft, yielding spots in the subgrade, areas having inadequate compaction, and deviations of the surface from the requirements set forth therein shall be corrected to line and grade and to all specified requirements.

10. **GRADE CONTROL.** The finished and completed subbase course shall conform to the lines, grades, and cross sections shown. The lines, grades and cross sections shown shall be maintained by means of line and grade stakes placed by the Contractor at the site of the work in accordance with the SECTION: SPECIAL CLAUSES.

11. **MIXING AND PLACING MATERIALS.** The materials shall be mixed and placed in such a manner as to obtain uniformity of the subbase material and at the water content specified. The Contractor shall make such adjustments in mixing or placing procedures or in equipment as may be directed to obtain the true grades, to minimize segregation and degradation, to reduce or accelerate loss or increase of water, and to insure a satisfactory subbase course.

12. **LAYER THICKNESS.** The compacted thickness of the subbase course shall be 8 inches. When a compacted layer of 6 inches or less is indicated, the material may be placed in a single layer; when a compacted thickness of more than 6 inches is required, no layer shall exceed 6 inches nor be less than 3 inches when compacted.

13. **COMPACTION.** Each layer of the subbase course shall be compacted with steel-wheeled rollers, light pneumatic-tired rollers, or other equipment, as approved. Water content shall be maintained during the compaction procedure at optimum or at the percentage directed by the Contracting Officer. In all places not accessible to the rollers, the mixture shall be compacted with mechanical tampers. Compaction shall continue until each layer is compacted through the full depth to at least 100 percent of laboratory maximum density. The Contractor shall make such adjustments in rolling or finishing procedures as may be needed to obtain true grades, to minimize segregation and degradation, to reduce or increase water content, and to insure a satisfactory subbase course. Any materials that are found to be unsatisfactory shall be removed and replaced with satisfactory material or reworked to produce a satisfactory material.

14. **EDGES OF THE SUBBASE COURSE.** The manner of construction and the type of edge required for subbase course will depend on the type of road section and the adjacent construction. The following edges shall be used at the locations shown on the drawings or designated by the typical pavement section.

    14.1. **WITH CURB AND GUTTER (WITHOUT SUBDRAINS).** Where the pavement section includes concrete curb and gutter, the subbase course shall terminate in

a vertical edge at the back of the curb and gutter. Approved material from excavation or borrow, as required, shall be placed along the vertical edge in such quantity as will compact to the thickness of the subbase course being constructed. The approved material shall be not less than three (3) feet in width and shall be rolled and compacted simultaneously with each layer of the subbase course.

14.2. **WITH CONCRETE STRAIGHT CURB.** Where the pavement section includes concrete straight curb, the subbase course which is below the bottom of the concrete straight curb shall be constructed as specified above for concrete curb and gutter consistent with the requirement of a minimum layer of 3-inch compacted thickness. The concrete straight curb shall then be constructed and backfilled prior to the construction of the balance of the subbase course. Care shall be exercised to preclude damaging the concrete or disturbing the grade of the completed concrete straight curb.

14.3. **WITH SHOULDERS.** Where the pavement section includes shoulders constructed of subbase, the subbase portion of the shoulders shall be constructed in the same manner and simultaneously with the subbase course under the surfacing. All requirements for the subbase course shall apply to the shoulders. The tapered edge of the shoulders shall be constructed in such manner as the Contractor elects subject to the approval of the Contracting Officer, but the finished surface of the shoulders and tapered edges shall conform to the line, grade, and section shown on the drawings.

15. **SMOOTHNESS TEST.** The surface of each layer shall not show deviations in excess of 3/8 inch when tested with a 10-foot straightedge applied parallel with and at right angles to the centerline of the area to be paved. Deviations exceeding this amount shall be corrected by removing material, replacing with new material, or reworking existing material and compacting, as directed. The Contractor shall test the surface smoothness in the presence of a representative of the Contracting Officer at intervals as directed.

16. **THICKNESS CONTROL.** The Contractor shall control his operations by measurements to insure placement of materials to the thickness specified. Thickness measurements shall be made by test holes at least 3 inches in diameter through the course. One depth measurement shall be made for each 500 square yards, or part thereof, of subbase course. Measurements may be made by the Government for verification of compliance; however, the Contractor shall not depend on such measurements for his control of operations. The completed thickness of the subbase course shall be within 1/2 inch plus or minus of the thickness shown for courses 6 inches and greater in total thickness and within 1/4 inch plus or minus for courses less than 6 inches in total thickness. Where the measured thickness of the subbase course is more than 1/2 inch deficient for courses, 6 inches and greater in total thickness and 1/4 inch deficient for courses less than 6 inches in total thickness, the Contractor shall correct such areas at no additional expense to the Government, by scarifying, adding mixture of proper gradation, reblading, and recompacting as directed. Where the measured thickness of the subbase course is more than 1/2 inch thicker than that shown on the drawings, it shall be considered as conforming with the specified thickness requirements plus 1/2 inch. The average job thickness shall be the average of the job measurements determined as specified above but shall be within 1/4 inch of the thickness shown on the drawing.

17. **MAINTENANCE.** The subbase course shall be maintained by the Contractor in a satisfactory condition until accepted.

January 1990

ZERO ACCIDENTS

SECTION 02551
BITUMINOUS INTERMEDIATE AND SURFACE COURSES
(CENTRAL PLANT HOT MIX)

INDEX

1. **APPLICABLE PUBLICATIONS.** The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

1.1. MILITARY STANDARD (MIL STD).

MIL-STD-620A	Test Methods for Bituminous Paving Materials & Notice 1

1.2. U.S. ARMY CORPS OF ENGINEERS HANDBOOK FOR CONCRETE AND CEMENT.

CRD-C 130-79	Scratch Hardness of Coarse Aggregate Particles
CRD-C 119-53	Flat and Elongated Particles in Coarse Aggregate (Rev Jun 63)

1.3. AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) STANDARDS.

C 29-87	Unit Weight and Voids in Aggregate
C 88-83	Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
C 117-87	Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
C 127-84	Specific Gravity and Absorption of Coarse Aggregate
C 128-84	Specific Gravity and Absorption of Fine Aggregate
C 131-87	Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
C 136-84a	Sieve Analysis of Fine and Coarse Aggregates
C 183-88	Sampling and Acceptance of Hydraulic Cement
C 566-84	Total Moisture Content of Aggregate by Drying
D 5-83	Penetration of Bituminous Materials
D 75-87	Sampling Aggregates
D 140-88	Sampling Bituminous Materials
D 242-85	Mineral Filler for Bituminous Paving Mixtures

D 946-82	Penetration-Graded Asphalt Cement for Use in Pavement Construction
D 1250-80	Petroleum Measurement Tables
D 1856-79 (R 1984)	Recovery of Asphalt from Solution by Absorption Method
D 2172-81	Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
D 3381-83	Viscosity-Graded Asphalt Cement for Use in Pavement Construction

2. **GENERAL DESCRIPTION.** Bituminous surface course shall be placed and compacted on a prepared base course. All quality control sampling and testing results and reports shall be included in the Contractor's Daily Quality Control Reports. Place bituminous surface to match thickness and elevation of existing pavement.

3. **SUBMITTALS.** In accordance with SECTION: SPECIAL CLAUSES, the Contractor shall submit the following items.

3.1. **CATEGORY I.** None.
3.2. **CATEGORY II.** (For Approval)
3.2.1. Aggregate Test Results. (Para. 9.2.1)
3.2.2. Certified Refinery Analysis. (Para. 9.3)
3.2.3. Mix Design. (Para. 13.1)

4. **PLANT, EQUIPMENT, MACHINES, AND TOOLS.**

4.1. **GENERAL.** The bituminous plant shall be of such capacity to produce the quantities of bituminous mixtures required. Hauling equipment, paving machines, rollers, miscellaneous equipment, and tools shall be provided in sufficient numbers and capacity and in proper working condition to place the bituminous paving mixtures at a rate equal to the plant output.

4.2. **MIXING PLANTS.** The mixing plant shall be an automatic or semiautomatic controlled commercially manufactured unit designed and operated to consistently produce a mixture within the job-mix formula (JMF). The plant shall have a minimum capacity of 100 tons per hour. Drum mixers shall be prequalified at the production rate to be used during actual mix production. The prequalification tests will include extraction and recovery of the asphalt cement in accordance with ASTM D 2172 and ASTM D 1856. The penetration of the recovered asphalt binder shall not be less than 60 percent of the original penetration, as measured in accordance with ASTM D 5.

4.3. **BITUMINOUS MATERIALS SPREADERS** shall be the self-propelled type equipped with hoppers, tamping, or vibrating devices, distributing screws, adjustable screeds operated either manually or automatically, equipment for heating the screeds, and equalizing devices. The spreader shall be capable of spreading hot bituminous mixtures without leaving indented areas, tearing, shoving, or gouging and capable of producing a finished surface conforming to the smoothness requirements specified hereinafter. The spreader shall be capable of confining edges of strips to true lines without use of stationary side forms and capable of placing the course to the required thickness. Spreaders shall be designed to operate forward at variable speeds and in reverse at traveling speeds of not less than 100 feet per minute. If an automatic grade control device is used on the spreader for two-lane paving operations, it shall consist of a sensing device for control of one end of the screed and a slope-control mechanism for control of the other end of the screed, or a sensing device on each side of the paving machine. Where the paver is used on multiple paving lanes (more than two paving lanes), sensing devices shall be used on each side of the spreader for control of the screed. The slope-control mechanism shall not be used for grade control in multiple paving lane operations.

4.4. **VIBRATORY ROLLERS** shall be self-propelled, double-drum, steel wheel vibratory rollers having an average operating weight per drum of at least 150 pounds per lineal inch of drum. The rollers shall transmit a dynamic impact to the surface through smooth steel drums by means of revolving weights, eccentric shafts, or other equivalent methods. The roller shall have a vibrating frequency of at least 1500 cycles per minute. The amplitude shall be between 0.015 inch and 0.040 inch at the operating frequency used. Controls shall permit ready variation of the amplitude at a minimum of two settings over at least 50 percent of the above range. The roller drum shall be between 48 and 66 inches in diameter and 66 to 96 inches in width. The roller shall be operated at speeds not exceeding 1.5 miles per hour. Within the range of the operational capability of the equipment, the Contracting Officer may direct or allow variations within the specified range to the frequency, amplitude, and speed of operation which result in the required density and satisfactory surface texture at the fastest production rate. Roller shall be equipped with some means of keeping the drums damp during operation. Each drum shall be equipped with an operating scraper and pad. Any rollers which pick up material from the surface of the pavement shall be adjusted, modified, or replaced.

4.4.1. **RUBBER-TIRED ROLLERS** shall be furnished for rolling the pavement surface after use of the vibratory or steel wheel roller. The rubber-tired roller shall have smooth tires, shall have non-oscillating wheels and shall be capable of being operated at a tire pressure between 50 and 90 psi and with a total load between 3,000 and 4,500 pounds per wheel. The roller shall have two axles with at least three wheels per axle, offset so that front and back tires do not track in the same path. At least one rubber-tired roller shall be used at all times during construction.

4.5. **STEEL-WHEEL ROLLERS** shall be self-propelled, three-wheel, (two- axle) or tandem (two-axle) types, weighing not less than 20,000 pounds each. The three-wheel rollers shall have a minimum weight of 300 pounds per inch of width of rear wheel. Wheels shall be equipped with adjustable scrapers water tanks, and sprinkling apparatus for keeping the wheels wet; thereby preventing the bituminous mixture from sticking to the wheels. Rollers shall be capable of reversing without backlash and free from worn parts. Roller wheels with flat and pitted areas or projections that leave marks in the pavement will not be permitted. Three-axle tandems will be permitted in lieu of two-axle tandems if approved by the Contracting Officer.

4.6. **SMALL TOOLS** shall consist of rakes, lutes, shovels, tampers, smoothing irons, pavement cutters, portable heater for heating small tools, and other small tools in numbers as required.

4.7. **STRAIGHTEDGE.** The Contractor shall furnish and maintain at the site, in good condition, one straightedge for each bituminous paver, for use of the Contracting Officer in testing the finished surface. Straightedges shall be aluminum or other approved lightweight metal and shall have blades of box or box-girder cross section with flat bottom, adequately reinforced to insure rigidity and accuracy. Straightedges shall have handles to facilitate movement on the pavement. Where devices other than straightedges are approved for surface smoothness determination, the Contractor shall furnish and maintain in good working condition at the site, one such device for each bituminous paver.

5. **WEATHER LIMITATIONS.** Bituminous courses shall be constructed only when the [base course] [intermediate course] [existing pavement] is dry and when the weather is not rainy. Unless otherwise directed, asphalt courses shall not be constructed when the temperature of the surface of existing pavement or base course is below 40 degrees F.

6. **PAVEMENT PROTECTION.** After final rolling, no vehicular traffic of any kind shall be permitted on the pavement until the pavement has cooled to 140 degrees F.

7. **SURFACE REQUIREMENTS.**

7.1. **BITUMINOUS SURFACE COURSE.** The surface course, upon completion of final rolling, shall be smooth and true to grade and cross section. When a 10-foot straightedge is laid on the surface parallel with the centerline, the surface shall not vary more than 1/8 inch from the straightedge. When the 10-foot straightedge is laid on the surface transverse to the centerline between the crown and edge of pavement, the surface shall not vary more than 1/4 inch from the straightedge. Low or defective areas shall be immediately corrected by cutting out the faulty areas and replacing with fresh, hot mixture, and compacting the area to conform to the remainder of the pavement. Testing for plan-grade conformance and surface smoothness shall be performed by the Contractor in the presence of a representative of the Contracting Officer immediately after rolling is completed. Tests shall be made at intervals as directed.

7.2. **PLAN GRADE.** The grade of the completed surface shall not vary more than 0.05 foot from the plan grade.

8. **GRADE CONTROL.** The lines and grades shown on the contract drawings shall be established and maintained by means of line and grade stakes placed at the site of the work by the Contractor in accordance with SECTION: SPECIAL CLAUSES. Elevations of bench marks used by the Contractor for controlling pavement operations at site of work will be determined, established, and maintained by the Government. Finished pavement gradelines and elevations shown shall be established and controlled at site of work by the Contractor in accordance with bench mark elevations furnished by the Contracting Officer.

9. **SAMPLING AND TESTING.**

9.1. **GENERAL.** All quality control sampling, testing and establishing of the bituminous mix design shall be the responsibility of the Contractor in accordance with paragraph: CONTRACTOR QUALITY CONTROL in SECTION: SPECIAL CLAUSES and as specified herein. All sampling, testing and establishing of the bituminous mix design shall be performed by an approved commercial testing laboratory. The Government may perform verification tests as considered necessary. Sampling shall be performed in accordance with ASTM Standard D 75 for aggregates and ASTM Standard C 183 for mineral filler, unless otherwise directed. Quality control tests shall be performed at the frequency specified hereinafter. Aggregates shall not be delivered to the job site or used in the production of bituminous mixtures without prior approval.

9.2. **SAMPLING, TESTING, AND APPROVAL OF BITUMINOUS MATERIALS.** A sample of the asphalt and a certified refinery analysis from the proposed source shall be furnished along with the proposed job-mix formula. In addition, a certified refinery analysis shall be furnished for each shipment of bituminous material delivered to the project. The Government may perform verification tests as considered necessary. During construction the Contractor shall furnish samples of each shipment of bituminous material received at the project and the samples will be tested and/or retained by the Government for record purposes until the completion of the contract. Sampling shall be in accordance with ASTM D 140.

9.3. **SAMPLING, TESTING, AND APPROVAL OF BITUMINOUS MIXTURES DURING CONSTRUCTION.**

9.3.1. **General.** Samples of plant mixtures shall be taken before the material is placed in the pavement and shall be tested to determine conformance to the specified test properties of bituminous mixtures and to determine bitumen content and aggregate gradation. All quality control sampling and testing shall be the responsibility of the Contractor in accordance with paragraph: CONTRACTOR QUALITY CONTROL in SECTION: SPECIAL CLAUSES and as specified herein. All testing shall be performed by an approved commercial testing laboratory. All tests shall be performed expeditiously and results immediately furnished the Contractor and Government representatives at the construction site or mixing plant. In no case, after construction commences, shall operations for any half day (morning or afternoon) commence until results of tests performed on samples taken during the previous half day are available, and adjustments in the mix made if necessary. The Government may perform verification tests as considered necessary. Mixtures that do not conform to the specified test properties shall be rejected. No payment will be made to the Contractor for mixtures rejected, for additional retesting, or for pavements or portions of pavement removed.

9.3.2. **Testing Frequency.**

9.3.2.1. **Marshall Tests.** One set (three specimens) of tests shall be made for each 300 tons of hot mix produced, except that a minimum of two sets per day shall be made.

9.3.2.2. **Extraction Tests** shall be made to determine bitumen content and aggregate gradation at the same frequency specified above for Marshall tests.

9.3.2.3. **Immersion Compression Tests.** One set of tests shall be made for the first day's construction and thereafter whenever there is any change in materials or job-mix formula.

9.3.2.4. **Moisture Tests.** If dryer-drum mixing process is used, the Contractor shall obtain samples of the bituminous mixture as it is discharged from the dryer-drum mixer and shall test for moisture. Frequency of sampling and testing shall consist of at least two samples during the first 4 hours of each day's production and at least one during the remainder of the day.

10. **SAMPLING PAVEMENTS.** Samples of finished pavement, including samples that span the longitudinal joints, shall be obtained by the Contractor. The type, size, and location of the samples shall be as directed, except that cores shall be at least 4 inches in diameter and sawed samples at least 5 inches on each side. The samples shall be tested by the Contractor to determine conformance to density, thickness and, if directed, other specified requirements. All quality control sampling and testing shall be the responsibility of the Contractor in accordance with paragraph: CONTRACTOR QUALITY CONTROL in SECTION: SPECIAL CLAUSES and as specified herein. All testing shall be performed by an approved commercial testing laboratory. Samples of each day's production shall be taken by noon of the following day and results of tests reported to the Contracting Officer by the end of that day. The Government may perform verification tests as considered necessary. The Contractor shall furnish a power saw or core drill and labor for cutting samples and shall immediately replace the pavement to the satisfaction of the Contracting Officer at no additional cost to the Government. One sample shall be taken and tested for each 200 tons or less of bituminous mixture placed each day, except that additional samples shall be taken and tested at the start of the paving operations when directed. However, the maximum

number of samples required each day shall be six. One-half of the samples shall be cut from longitudinal joints.

11. **INSPECTION OF PLANT AND EQUIPMENT.** The Contracting Officer shall have access at all times to all parts of the paving plant for checking adequacy of equipment in use, for inspecting operation of plant, verifying weights, proportions, and character of materials, and for checking temperatures maintained in preparation of mixtures. Checks so made shall not relieve the Contractor from performing all work as specified.

12. **BITUMINOUS HOT MIX.** Bituminous hot mix shall consist of coarse aggregate, fine aggregate, mineral filler, bituminous material, and approved additives, if required, of the qualities and in the proportions specified and shall conform to the requirements contained in Paragraph: PROPORTIONING OF MIXTURE.

12.1. **AGGREGATES** shall consist of crushed stone, crushed gravel, screenings, sand, and mineral filler. The portion of these materials retained on the No. 4 sieve shall be known as coarse aggregate; the portion passing the No. 4 sieve and retained on the No. 200 sieve, as fine aggregate; and the portion passing the No. 200 sieve, as mineral filler. The coarse and fine aggregates and mineral filler shall be so graded and of such character that when combined, a blend will be produced that will meet the requirements specified in subsequent paragraphs entitled AGGREGATE GRADATION and COMPOSITION OF MIXTURE.

12.1.1. **Coarse Aggregates** shall consist of clean, sound, durable fragments of crushed stone or crushed gravel meeting the following requirements.

12.1.1.1. **Percentage of Wear** shall not exceed 40 after 500 revolutions, as determined in accordance with ASTMC 131.

12.1.1.2. **Percentage of Loss** shall not exceed 18 after five cycles performed in accordance with ASTM C 88, using magnesium sulfate.

12.1.1.3. **Crushed Gravel** retained on the No. 4 sieve and each coarser sieve listed in paragraph: AGGREGATE GRADATION shall contain at least 60 percent by weight of crushed pieces having two or more fractured faces. When two fractures are contiguous, the angles between planes of fractures shall be at least 30 degrees to count as two fractured faces.

12.1.1.4. **Particle Shape** of crushed aggregates shall be essentially cubical. The quantity of flat and elongated particles in any sieve size shall not exceed 20 percent by weight, when determined in accordance with CRD-C 119.

12.1.2. **Fine Aggregates** shall consist of clean, durable natural sands; manufactured sands prepared by crushing stone [, slag] or gravel; or any combination of natural and manufactured sands. Natural sands shall consist of grains of clean, hard, durable rock. Quantity of natural sand to be added to the surface [and intermediate] course mixtures shall not exceed 25 percent by weight of coarse and fine aggregate and material passing the No. 200 sieve. Natural sand shall be clean and free from clay and organic matter. Fine aggregate produced by crushing shall have at least 90 percent by weight of crushed particles having two or more fractured faces in the portion retained on the No. 30 sieve.

12.1.2.1. **Mineral Filler.** Mineral filler shall conform to ASTM Standard D 242 and the following additional requirements. At least 50 percent of the mineral filler shall be hydrated lime, limestone dust, or Portland cement. However, in areas where long service has shown that there has been no problem with stripping when the proposed aggregates are used, this additional requirement may be waived by the Contracting Officer when requested in writing.

12.1.3. **Bulk-Impregnated Specific Gravity** of the aggregates shall be determined in accordance with Method 105 of Military Standard MIL-STD-620.

12.1.4. **Aggregate Gradation.** Mineral aggregate shall be of such size that the percentage composition by weight, as determined by ASTM Standards C 136 and C 117, will conform to one of the gradations specified at the end of this paragraph. The gradations shown represent the extreme limits which shall determine suitability of aggregate for use from all sources of supply. The aggregate as finally selected for use in the work shall have a gradation within the limits specified, and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve or vice versa, but shall be uniformly graded from coarse to fine. The table is based on aggregates of uniform specific gravity, and the percentages passing the various sieves may be changed by the Contracting Officer when aggregates of varying specific gravities are used. Regardless of the gradation option chosen by the Contractor, it shall be his responsibility to furnish a combined aggregate which will produce a bituminous mixture meeting all requirements specified herein, particularly those specified in paragraph: COMPOSITION OF MIXTURE and any aggregate which fails to produce a bituminous mixture meeting all requirements specified shall be rejected and replaced with a satisfactory aggregate at no additional cost to the Government, and with no extension of time due to any delay caused by such replacement.

TABLE 1

Percent Passing, by Weight

Sieve Size	1-inch Maximum	3/4-inch Maximum [Surface Course]	1/2-inch Maximum
1 inch	100		
3/4 inch	83-97	100	
1/2 inch	72-90	80-98	100
3/8 inch	66-84	73-91	77-95
No. 4	51-69	57-75	57-75
No. 8	38-56	44-62	44-62
No. 16	28-46	32-50	32-50
No. 30	18-36	22-40	22-40
No. 50	11-27	13-29	13-29
No. 100	8-18	7-19	7-19
No. 200	2-7	2-7	2-7

13. PROPORTIONING OF MIXTURE.

13.1. **JOB-MIX FORMULA.** The proposed mix design, aggregate test results, and certified refinery analysis shall be submitted to the Contracting Officer 45 days before production of bituminous mixture. The Contracting Officer will submit the data directly to the Missouri River Division (MRD) Laboratory, 420 South 18th Street, Omaha, Nebraska, for approval. No bituminous mixture shall be

produced until the job-mix formula determined from the bituminous mix design has been approved by the MRD Laboratory. The bituminous mix design shall be established in accordance with MIL-STD-620A, Method 100. The formula will indicate the percentage of each sieve fraction of aggregate and the percentage of asphalt and temperature of completed mixture when discharged from mixer. The job-mix formula will be allowed the following tolerances.

Aggregate passing No. 4 sieve or larger	5 percent plus or minus
Aggregate passing Nos. 8, 16, 30 and 50 sieves	4 percent plus or minus
Aggregate passing Nos. 100 and 200 sieves	2 percent plus or minus
Asphalt as determined by extraction tests made in accordance with ASTM D 2172	0.25 percent plus or minus
Temperature of mixing	25 degrees F. plus or minus

The bitumen content and aggregate gradation may be adjusted within the limits of the tables specified herein to improve the paving mixtures, as directed, without adjustments in the contract price. The percentages of each sieve fraction in the job-mix formula will be restricted to values such that the application of the above-listed tolerances will not cause the limits of the gradation tables to be exceeded.

13.2. **TEST PROPERTIES OF BITUMINOUS MIXTURES.** The finished mixture shall meet the requirements hereinafter described when tested in accordance with MIL-STD-620A.

13.2.1. Stability, Flow and Voids.

13.2.1.1. **For Nonabsorptive Aggregate.** When the water absorption value of the entire blend of aggregate does not exceed 2.5 percent as determined by ASTM Standards C 127 and C 128, the aggregate will be designated as nonabsorptive. The apparent specific gravity shall be used in computing the voids total mix and voids filled with bitumen, and the mixture shall meet the following requirements.

Test Property	Base Course
Stability, minimum, pounds	500
Flow, maximum, 1/100-inch units	20
Voids, total mix, percent	3 - 5
Voids, filled with bitumen, percent	75 - 85

13.2.2. Reduction in Stability by Immersion. If the index of retained stability of the specimens of composite mixture is less than 76, when tested in accordance with the Immersion Compression Test described in MIL-STD-620A, the aggregates shall be rejected or the bitumen shall be treated with an approved anti-stripping agent. The amount of anti-stripping agent to be added to the bitumen shall be sufficient, as approved by the Contracting Officer, to produce an index of retained stability greater than 75 when specimens of the mixture conforming to the proposed job mix formula using the treated bitumen are tested in accordance with the immersion compression test described in MIL-STD-620A. No additional payment will be made to the Contractor for any addition of anti-stripping agent that may be required.

13.2.3. Moisture Content. If dryer-drum mixing process is used, the moisture content of the bituminous mixture shall not exceed 3.0 percent when

discharged from the dryer-drum mixer. Samples of bituminous material for moisture determination shall consist of not less than 10 pounds of material obtained at one time immediately after discharge from the mixer. Moisture content shall be determined by the same process specified for hot bin aggregate samples in paragraph: WATER CONTENT OF AGGREGATES, using the same type containers, except only one sample is used and there is no weighted average to be computed.

13.3. **CONTRACTOR'S OPTION.** At the option of the Contractor, in lieu of developing a new job-mix formula for surface course construction, the Contractor may use job-mix formulas for surface course construction currently in use on another nearby Corps of Engineers project or currently in use by the Colorado State Highway Department for surface courses for primary road construction provided in each instance that the same materials proposed for use on this project are being used and provided the mix meets all criteria specified in subparagraph: Properties of Bituminous Mixtures. If the Contractor proposes to use such other in-use job-mix formula, the proposed job-mix formula plus certified results of tests performed by a commercial laboratory showing that the job-mix formula meets all requirements specified herein shall be submitted to the Contracting Officer at least 45 days prior to commencing construction. The Contracting Officer will submit the data directly to the MRD Laboratory for approval. Use of this option will permit no changes to aggregate requirements or to other requirements specified in this section and shall not be the basis for additional cost to the Government or extension of time.

14. **CONDITIONING OF BASE COURSE.** Previously constructed base course shall be conditioned as specified herein. Prior to laying the bituminous course, the surface shall be cleaned of loose and foreign matter by sweeping with power sweepers, power brooms, or hand brooms, as directed.

14.1. **BASE COURSE.** The surface of base course will be inspected by the Contracting Officer for adequate compaction and surface tolerances as specified in SECTION: CRUSHED AGGREGATE BASE COURSE. Unsatisfactory areas shall be corrected as approved or directed.

14.2. **EXISTING PAVEMENT.**

15. **PREPARATION OF BITUMINOUS MIXTURES.** Rates of feed of aggregates shall be regulated so that the moisture content and temperature of aggregates will be within specified tolerances. Aggregates, mineral filler, and bitumen shall be conveyed into the mixer in proportionate quantities required to meet the job mix formula. Mixing time shall be as required to obtain a uniform coating of the aggregate with the bituminous material. Temperature of bitumen at time of mixing shall not exceed 300 degrees F. Temperature of aggregate and mineral filler in the mixer shall not exceed 325 degrees F. when bitumen is added. Overheated and carbonized mixtures or mixtures that foam shall not be used.

15.1. **WATER CONTENT OF AGGREGATES.** During drying operations the water content shall be reduced to less than 0.25 percent for aggregate blends with water absorption of 2-1/2 percent or less, and to less than 0.50 percent for aggregate blends with water absorption greater than 2-1/2 percent, absorption to be determined by ASTM Standards C 127 and C 128. The water absorption for the aggregate blend shall be the weighted average of the absorption values for the coarse aggregate and the fine aggregate. The water content test shall be conducted in accordance with ASTM C 566. Water content for the blend will be a weighted average based on the composition of the blend.

15.2. **STORAGE OF BITUMINOUS PAVING MIXTURE** shall conform to the applicable requirements of ASTM D 3515; however, in no case shall the mixture be stored for more than 4 hours.

16. **TRANSPORTATION OF BITUMINOUS MIXTURE.** The bituminous mixture shall be transported from the mixing plant to the site in trucks having tight, clean, smooth beds coated with a minimum amount of a concentrated solution of hydrated lime and water to prevent adhesion of the mixture to the truck beds. Each load of mixture shall be covered with canvas, or other suitable material, of ample size to protect the mixture from the weather and to prevent loss of heat. Deliveries shall be scheduled so that spreading and rolling of all mixture prepared for 1 day's run can be completed during daylight unless approved adequate artificial lighting is provided. The mixture shall be delivered in such manner that the temperature at the time of dumping into the spreader will be not less than hereinafter specified. Loads that have crusts of cold, unworkable material or have become wet by rain will be rejected. Hauling over freshly placed material will not be permitted.

17. **PLACING.**

17.1. **SURFACE PREPARATION OF UNDERLYING COURSE.** Prior to placing of the intermediate or surface course, the underlying course shall be cleared of all foreign or objectionable matter with power blowers, power brooms, or hand brooms.

17.2. **SPRAYING OF CONTACT SURFACES OF STRUCTURES.** Contact surfaces of previously constructed shall be sprayed with a thin coat of bituminous material conforming to the requirements of SECTION: BITUMINOUS [PRIME] [TACK] COAT.

17.3. **OFFSETTING JOINTS IN INTERMEDIATE AND SURFACE COURSES.** The surface course shall be placed so that longitudinal joints of the surface course will not coincide with joints in the intermediate course by at least 1 foot. Transverse joints in the surface course shall be offset by at least 2 feet from transverse joints in the intermediate course.

17.4. **GENERAL REQUIREMENTS FOR USE OF MECHANICAL SPREADER.** The range of temperatures of the mixtures, when dumped into the mechanical spreader shall be as determined by the Contractor. Asphalt mixtures having temperatures less than 250 degrees F. when dumped into a mechanical spreader will be rejected. The mechanical spreader shall be so adjusted and its speed so regulated that the surface of the course being placed will be smooth and continuous without tears and pulling, and of such depth that, when compacted, the surface will conform with the cross section, grade, and contour shown on the drawings. Unless otherwise directed, placing shall begin along the centerline of areas paved on a crowned section or on the high side of areas with a one-way slope, and shall be in the direction of the major traffic flow. The mixture shall be placed in consecutive adjacent strips having a minimum width of 10 feet, except when edge lanes require strips less than 10 feet to complete an area. Each strip placed before a succeeding strip shall be of such length that sufficient heat will be retained to make the strip readily compatible so that a joint can be obtained conforming to the requirements for texture, density, and smoothness specified in the paragraph: JOINTS. The length of any strip to be laid prior to the succeeding strip shall be as directed and may be decreased or increased as dictated by changes in climatic conditions. Longitudinal joints and edges shall be constructed to true line markings. The Contractor shall establish lines parallel to the centerline of the area to be paved and shall place string lines coinciding with established lines for the spreading machine to follow. Number and location of lines shall be as directed. Placing of the mixture shall be as nearly continuous as possible, and the speed of placing shall be adjusted, as directed, to permit proper rolling.

17.5. **SPECIAL REQUIREMENTS FOR PLACING STRIPS SUCCEEDING INITIAL STRIPS.** In placing each succeeding strip after the initial strip has been spread

and compacted as specified hereafter, the screed of the mechanical spreader shall overlap the previously placed strip 3 to 4 inches and shall be sufficiently high so that compaction will produce a smooth, dense joint. Mixture placed on the edge of the previously placed strip by the mechanical spreader shall be pushed back to the edge of the strip being placed by use of a lute. When the quantity of mixture on the previously placed strip plus uncompacted material in the strip being placed exceeds that required to produce a smooth, dense joint, the excess mixture shall be removed and wasted.

17.6. **SHOVELING, RAKING, AND TAMPING AFTER MACHINE SPREADING.** A sufficient number of experienced shovelers and rakers shall follow the spreading machine, adding hot mixture and raking the mixtures as required to produce a course that, when completed, will conform to all requirements specified herein. Broadcasting or fanning of mixture over areas being compacted will not be permitted. When segregation occurs in the mixture during placing, the spreading operation shall be suspended until the cause is determined and corrected. Irregularities in alinement of the course left by the mechanical spreader shall be corrected by trimming directly behind the machine. Immediately after trimming, the edges of the course shall be thoroughly compacted by tamping laterally with a lute. Distortion of the course during tamping will not be permitted.

17.7. **HAND SPREADING IN LIEU OF MACHINE SPREADING.** In areas where the use of machine spreading is impractical, the mixture shall be spread by hand. Spreading shall be in a manner to prevent segregation. The mixture shall be spread uniformly with hot shovels and hot rakes in a loose layer of a thickness that, when compacted, will conform to the required grade and thickness. During hand spreading, each shovelful of mixture shall be carefully placed by turning the shovel over in a manner that will prevent segregation. In no case shall the mixture be placed by throwing or broadcasting from a shovel. The loads shall not be dumped faster than can be properly handled by the shovelers and rakers.

18. COMPACTION OF MIXTURE.

18.1. **GENERAL.** Compaction of the mixture shall be accomplished by the vibratory rollers and/or steel-wheel rollers and rubber-tired rollers specified above. The initial rolling with the vibratory or steel-wheel roller shall begin as soon after placing as the mixture will bear a roller without undue displacement. Intermediate rolling with the rubber-tired roller shall follow the initial rolling as closely as possible and shall be done while the paving mix is still at a temperature that will result in maximum density. Finish rolling with the steel-wheel roller shall be accomplished while the material is still workable enough to remove roller marks. Delays in rolling freshly spread mixture will not be permitted. After initial rolling, preliminary tests of crown, grade, and smoothness shall be made by the Contractor under supervision of the Contracting Officer. Before rolling is continued, deficiencies shall be corrected so that finished course will conform to requirements for grade and smoothness specified herein. Further smoothness checks shall be made by the Contractor as directed by the Contracting Officer. After preliminary smoothness tests, rolling shall be continued until density is obtained in all portions of each course of not less than 95 percent of density of laboratory compacted specimens of same mixture.

18.2. **DENSITY TESTS.** Density of the compacted mixture of the surface [or intermediate] course shall be determined by tests made on specimens taken from the compacted course in accordance with the requirements of paragraph: SAMPLING PAVEMENTS. Specimens shall be tested in accordance with the requirements of Method 101 of MIL-STD-620A.

18.3. **OPERATION OF ROLLERS AND TAMPERS.** The speed of rollers shall be slow enough at all times to avoid displacement of the hot mixture. Displacement

of the mixture resulting from reversing the direction of the roller or from any other cause shall be corrected at once by use of rakes, and fresh mixture shall be applied or removed where necessary. Alternate passes of the roller shall be varied slightly in length. During rolling, the wheels of the vibratory and steel-wheel rollers shall be moistened to prevent adhesion of the mixture to the wheels, but excess water will not be permitted. Tires of rubber-tired rollers shall be moistened with soapy water when required to prevent mixture from sticking to tires during rolling. Rollers shall not be permitted to stand on finished courses until the courses have thoroughly cooled. The minimum number of rollers furnished by the Contractor for each spreading machine operating on the job shall be one vibratory roller, one rubber-tired roller, and one steel-wheel roller or two steel-wheel rollers and one rubber-tired roller. Places inaccessible to rollers shall be thoroughly compacted with hot hand-tampers.

18.4. **TESTING OF MIXTURE.** At the start of the plant operation, a quantity of mixture shall be prepared that is sufficient to construct a test section at least 50 feet long, two spreader widths wide and of thickness to be used in the project. Mixture shall be placed, spread, and rolled with equipment to be used in the project and in accordance with the requirements specified above. This test section shall conform to all specified requirements. If test results are satisfactory, the test section shall remain in place as part of the completed pavement. If tests indicate that the pavement does not conform to specification requirements, necessary adjustments to plant operations and rolling procedures shall be made immediately, and the entire test section shall be removed, and an additional test section shall be constructed until an acceptable test section is constructed, all at no additional cost to the Government.

18.5. **CORRECTING DEFICIENT AREAS.** Mixtures that become contaminated or are defective shall be removed. Skin patching of an area that has been rolled will not be permitted. Holes the full thickness of the course shall be cut so that the sides are perpendicular and parallel to the direction of traffic and the edges are vertical. Edges shall be sprayed with bituminous materials. Sufficient fresh paving mixture shall be placed in the holes so that finished surface will conform to the grade and smoothness requirements. The paving mixture shall be compacted to the density specified herein.

19. **JOINTS.**

19.1. **GENERAL.** Joints between successive day's work, or joints that have become cold because of delay, shall be made carefully to insure continuous bond between old and new sections of the course. All joints shall have the same texture, density, and smoothness as other sections of the course. Contact surfaces of previously constructed pavements that have become coated with dust, sand, or other objectionable material shall be cleaned by brushing or cut back with an approved power saw or other approved device, as directed. The surface against which new material is to be placed shall be sprayed with a thin, uniform coat of bituminous material. The material shall be applied far enough in advance of placement of the fresh mixture to insure adequate curing. Care shall be taken to prevent damage or contamination of the sprayed surface.

19.2. **TRANSVERSE JOINTS.** The roller shall pass over the unprotected end of freshly placed mixture only when placing of the course is discontinued or when delivery of mixture is interrupted to the extent that unrolled material may become cold. In all cases, the edge of the previously placed course shall be cut back to expose an even, vertical surface the full thickness of the course. In continuing placement of strip, the mechanical spreader shall be positioned on the transverse joint so that sufficient hot mixture will be spread to obtain a joint after rolling which conforms to the required density and smoothness

specified herein. When required, the fresh mixture shall be raked against the joints, thoroughly tamped with hot tampers, smoothed with hot irons and rolled.

19.3. **LONGITUDINAL JOINTS.** Edges of previously placed strips that have cooled or are irregular, honeycombed, poorly compacted, damaged, or otherwise defective, and unsatisfactory sections of the joint shall be cut back to expose a clean, sound surface for the full thickness of the course as directed. When required, fresh mixtures shall be raked against the joint, thoroughly tamped with hot tampers, smoothed with hot irons and rolled.

19.4. **EDGES OF PAVEMENT** adjacent to the shoulders shall be trimmed neatly to line. An earth berm of selected material not less than 1 foot wide shall be placed against and to the full height of the pavement surface as soon as practicable after final rolling has been completed and the pavement has sufficiently hardened.

ZERO ACCIDENTS

SECTION 02710
SEWERS; SANITARY, GRAVITY

INDEX

1. **APPLICABLE PUBLICATIONS.** The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

1.1. FEDERAL SPECIFICATION (Fed. Spec.).

RR-F-621C Frames, Covers, Gratings, Steps, Sump and Catch Basin, Manhole

1.2. NOT USED.

1.3. AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) PUBLICATIONS.

A 48-83 Gray Iron Castings
A 74-87 Cast Iron Soil Pipe and Fittings
A 123-84 Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
C 14-82 Concrete Sewer, Storm Drain, and Culvert Pipe
C 33-86 Concrete Aggregates
C 76-85a Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
C 94-86b Ready-Mixed Concrete
C 150-86 Portland Cement
C 260-86 Air-Entraining Admixtures for Concrete]
C 270-86b Mortar for Unit Masonry
C 425-86 Compression Joints for Vitrified Clay Pipe and Fittings (R 1982)
C 443-85a Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets
C 478-87 Precast Reinforced Concrete Manhole Sections
C 541-83 Linings for Asbestos-Cement Pipe
C 700-88 Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated
D 2412-87 External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading
D 2680-87 Acrylonitrile-Butadiene-Styrene (ABS) and Poly (Vinyl Chloride)(PVC) Composite Sewer Piping
D 2751-83a Acrylonitrile-Butadiene-Styrene (ABS) Sewer Pipe and Fittings
D 3034-85b Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
D 3212-86 Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
D 3262-87 "Fiberglass" (Glass-Fiber Reinforced Thermosetting Resin) Sewer Pipe
D 3840-81 Reinforced Plastic Mortar Pipe Fittings for Nonpressure Applications

F 402-80	Safe Handling of Solvent Cements and Primers Used for Joining Thermoplastic Pipe and Fittings
F 949-86a	Poly(Vinyl Chloride) (PVC) Corrugated Sewer Pipe With a Smooth Interior and Fittings

1.4. **NATIONAL FIRE PROTECTION ASSOCIATION (NFPA) STANDARDS.**

No. 49-1975	Hazardous Chemicals Data
No. 325M-1984	Fire Hazard Properties of Flammable Liquids, Gases and Volatile Solids
No. 704-1985	Standard System for the Identification of the Fire Hazards of Materials

2. **GENERAL.** Gravity sanitary sewers shall be constructed in conformance with this section of the specifications. Installation of force mains shall conform to requirements of SECTION: FORCE MAINS; SEWER. The construction required herein shall include appurtenant structures and building sewers to points of connection with the building drains 5 feet outside the buildings to which the sewer system is to be connected. Reducing fittings shall be provided as necessary to accommodate different pipe sizes. Excavation and backfilling shall conform to SECTION: EXCAVATION, TRENCHING, AND BACKFILLING FOR UTILITIES SYSTEMS. Backfilling shall be accomplished only after inspection and approval of the Contracting Officer. Work covered by this section will not be accepted until backfilling connected with the work has been completed satisfactorily.

3. **SUBMITTALS.** In accordance with SECTION: SPECIAL CLAUSES, the Contractor shall submit, for approval, data as specified herein on the following:

3.1. **CATEGORY I.** None.

3.2. **CATEGORY II.** (For Information Only)
PVC Pipe

4. **MATERIALS** shall conform to the respective specifications and other requirements specified below:

4.1. **PIPE** may be of any of the following materials unless otherwise specified or shown. Pipe and fittings utilized for waste lines shall be oil resistant.

4.1.1. Plastic Pipe.

4.1.1.1. Acrylonitrile-butadiene-styrene (ABS) Composite Piping. ASTM D 2680, type SC or type OR, size 8-inch through 15-inch diameter.

4.1.1.2. Acrylonitrile-butadiene-styrene (ABS) Pipe and Fittings. ASTM D 2751, solvent weld or bell and socket o-ring joint, size 12 inch or less in diameter.

4.1.1.3. Poly(Vinyl Chloride) (PVC) Pipe and Fittings. ASTM D 3034, type PSM with a maximum SDR of 35, size 15 inch or less in diameter, with flexible elastomeric seal joint. ASTM F 949 for corrugated sewer pipes with a smooth interior and fittings of 4, 6, 8, and 10 inches in diameter.

4.1.1.4. Reinforced Plastic Mortar Pipe and Fittings. Pipe shall conform to ASTM D 3262. Fittings shall conform to ASTM D 3840 and shall be compatible with the pipe supplied. Fittings shall have a strength equal to or greater than the pipe.

4.1.1.5. **Joints.**

4.1.1.5.1. **Acrylonitrile-butadiene-styrene (ABS) Composite Pipe.** Type SC or OR, in accordance with ASTM D 2680.

4.1.1.5.2. **Acrylonitrile-butadiene-styrene (ABS) Pipe.** Solvent cement or elastomeric joint in accordance with ASTM D 2751, dimensions and tolerances in accordance with Table 2 therein.

4.1.1.5.3. **Poly(Vinyl Chloride) (PVC) Pipe.** Elastomeric gasket joint in accordance with the requirements of ASTM D 3212.

4.1.1.5.4. **Reinforced Plastic Mortar Pipe.** Elastomeric gasket joints shall comply with the manufacturers' recommendations.

4.1.1.6. **Branch Connections.** Branch connections shall be made by use of regular fittings or solvent cemented saddles as approved by the Contracting Officer. Saddles for acrylonitrile-butadiene-styrene (ABS) composite pipe shall comply with Figure 2 of ASTM D 2680, saddles for acrylonitrile-butadiene-styrene (ABS) pipe shall comply with Table 3 of ASTM D 2751, and saddles for poly(vinyl chloride) (PVC) pipe shall comply with Table 4 of ASTM D 3034.

4.1.1.7. **Protection of Material.** Before, during, and after installation, plastic pipe and fittings shall be protected from exposure to sunlight and any environment that would result in damage or deterioration to the material. Solvents, solvent compounds, lubricants, elastomeric gaskets, and any similar materials required to install the plastic pipe shall be stored in accordance with the manufacturer's recommendation and shall be discarded if the storage period exceeds the recommended shelf life. Solvents in use will be discarded when the recommended pot life is exceeded.

4.2. **NOT USED.**

4.3. **CEMENT MORTAR.** ASTM C 270, type M. Use type IIA cement.

4.4. **NOT USED.**

4.5. **PORTLAND CEMENT.** ASTM C 150, type II or air-entrained V for concrete used in manholes. Cement used in concrete cradle and encasement may be Type I.

4.6. **PORTLAND CEMENT CONCRETE.** ASTM C 94, compressive strength of 4,000 p.s.i. at 28 days. Concrete in place shall be protected from freezing and moisture loss for 7 days.

4.7. **PRECAST REINFORCED CONCRETE MANHOLE SECTIONS.** ASTM C 478. Cement used in the manufacture of the precast units shall conform to the paragraph: Portland Cement For Manufacture of Concrete Pipe and Fittings. Joints shall be of mortar, or an approved mastic or rubber gasket, or an approved combination of these.

5. INSTALLATION.

5.1. ADJACENT FACILITIES.

5.1.1. **Water Lines.**

5.1.1.1. **Horizontal Separation.** Where the location of the sewer is not clearly defined on the drawings, the sewer line shall not be closer horizontally than 10 feet to a water distribution or service line. In cases where this is not practical, a horizontal spacing of 6 feet may be used if the water line is at least a minimum of 12 inches above the top of the sewer pipe. In no case shall water and sewer lines be installed in the same trench.

5.1.1.2. **Crossings.** Where water lines cross either above or below sewer lines, a minimum vertical separation of 18 inches shall be provided. Where a gravity sewer line crosses above the water line, a 20-foot section of sewer pipe capable of withstanding 15 psi internal pressure, including all joints within this section, shall be centered over the crossing. No joint within this section shall be located closer than 6 feet of the crossing.

5.1.1.3. **Special Conditions.** When it is impossible to obtain proper horizontal and vertical separation as stipulated above, the water line shall be relocated as shown on the drawings to provide these required separations. The requirements for the relocation of the water line shall be in conformance with SECTION: WATER LINES.

5.1.1.4. **Roads and Railroads.** Where shown on the drawings, sewerlines crossing primary access roads, airfield runways and taxiways shall be encased and installed in a rigid casing conforming to SECTION: EXCAVATION, TRENCHING, AND BACKFILLING FOR UTILITIES SYSTEMS.

5.2. PIPE LAYING.

a. Pipe shall be protected during handling against impact shocks and free fall and the pipe interior shall be free of extraneous material.

b. Pipe laying shall proceed upgrade with the spigot ends of bell-and-spigot pipe and tongue ends of tongue-and-groove pipe pointing in the direction of the flow. Each pipe shall be laid accurately to the line and grade shown on the drawings. Pipe shall be laid and centered so that the sewer has a uniform invert. As the work progresses, the interior of the sewer shall be cleared of all superfluous materials.

c. Before making pipe joints, all surfaces of the portions of the pipe to be joined shall be clean and dry. Lubricants, primers, and adhesives shall be used as recommended by the pipe manufacturer. The joints shall then be placed, fitted, joined, and adjusted so as to obtain the degree of water tightness required.

d. ABS composite pipe ends with exposed truss and filler material shall be thoroughly coated with solvent-weld material before making the joint to insure that there will be no water or air passage at the joint between the inner or outer wall of the pipe.

e. Installations of solvent-weld joint pipe, using ABS or PVC pipe and fittings shall be installed in accordance with ASTM F 402, and all required precautions shall be taken to assure adequate trench ventilation and protection for workers installing the pipe.

5.2.1. **Trenches** shall be kept free of water and as dry as possible during bedding, laying, and jointing and for as long a period as required. When work is not in progress, open ends of pipe and fittings shall be satisfactorily closed so that no trench water or other material will enter the pipe or fittings.

5.2.2. **Backfill.** As soon as possible after the joint is made, sufficient backfill material shall be placed along the pipe to prevent pipe movement off line or grade. Plastic pipe shall be completely covered to prevent damage from ultraviolet light.

5.2.3. **Width of Trench.** If the maximum width of the trench at the top of the pipe, as specified in SECTION: EXCAVATION, TRENCHING, AND BACKFILLING FOR UTILITIES SYSTEMS, is exceeded for any reason other than by direction, the Contractor shall install at no additional cost to the Government such concrete cradling, pipe encasement, or other bedding as may be required to satisfactorily support the added load of the backfill.

5.2.4. **Joints Between Different Pipe Materials** shall be made as hereinbefore specified, using approved jointing materials.

5.2.5. **Handling and Storage.** Pipe, fittings and joint material shall be handled and stored in accordance with the manufacturer's recommendations. Storage facilities for plastic pipe, fittings, joint materials and solvents shall be classified and marked in accordance with NFPA Standard 704, with classification as indicated in NFPA 49 and NFPA 325M.

5.3. **LEAKAGE TESTS.** Lines shall be tested for leakage by either infiltration tests or exfiltration tests, as appropriate. Prior to testing for leakage, the trench shall be backfilled up to at least the lower half of the pipe and with sufficient additional backfill to prevent pipe movement during testing, leaving the joints uncovered to permit inspection. Visible leaks encountered shall be corrected regardless of leakage test results. When the water table is 2 feet or more above the top of the pipe at the upper end of the pipeline section to be tested, infiltration shall be measured using a suitable weir or other device acceptable to the Contracting Officer. When the Contracting Officer determines that infiltration cannot be properly tested, an exfiltration test shall be made by filling the line to be tested with water so that a head of at least 2 feet is provided above both the water table and the top of the pipe at the upper end of the pipeline to be tested. The filled line shall be allowed to stand until the pipe has reached its maximum absorption, but not less than 4 hours. After absorption, the head shall be re-established. The amount of water required to maintain this water level during a 2-hour test period shall be measured. Leakage, as measured by either the infiltration test or exfiltration test, shall not exceed 0.16 gallon per inch diameter per 100 feet of pipeline per hour. When leakage exceeds the maximum amount specified, satisfactory correction shall be made and retesting accomplished. Testing, correction, and retesting shall be made at no additional cost to the Government.

5.4. **TEST FOR DEFLECTION.** When flexible pipe is used, a deflection test shall be made on the entire length of the installed pipeline on completion of all work, including the leakage test, backfill, and placement of any fill, grading, paving, concrete, or superimposed loads. Flexible plastic pipe is defined as plastic pipe having a pipe stiffness of less than 150 p.s.i. in accordance with ASTM D 2412. Deflection shall not exceed 5 percent of the base inside pipe diameters listed in ASTM D 3034. Deflection shall be determined by use of a deflection device or by use of a GO/NO GO mandrel. Mandrel dimensions shall be determined as stated in Appendix XI of ASTM D 3034 with a machining tolerance of 0.01 inch. Failure of the mandrel to pass freely through a pipe run shall be cause for rejection of that run. When a deflection device is used for the test in lieu of the mandrel described hereinbefore, such device shall be approved by the Contracting Officer prior to use. The device shall be sensitive to 1.0 percent of the diameter of the pipe being measured and shall be accurate to 1.0 percent of the indicated dimension. Installed pipe showing deflections of 5.0 percent shall be retested by a run from the opposite direction. If the retest indicates a deflection in excess of the 5.0 percent, the suspect pipe shall be replaced. Any pipe showing

deflections in excess of 5 percent at the end of 1 year following installation and acceptance will be replaced at no cost to the Government.

6. MANHOLES.

6.1. **GENERAL.** Manholes shall be constructed of precast concrete rings, with cast iron frames and covers, and in accordance with the drawings. The invert channels shall be smooth and semicircular in shape conforming to the inside of the adjacent sewer section. Changes in direction of flow shall be made with a smooth curve of as large a radius as the size of the manhole will permit. Changes in size and grade of the channels shall be made gradually and evenly. The invert channels shall be formed directly in the concrete of the manhole base, or shall be built up with brick and mortar, or shall be half tile laid in concrete, or shall be constructed by laying full section sewer pipe through the manhole and breaking out the top half after the surrounding concrete has hardened. Pipe connections shall be made to manholes using water stops, standard o-ring joints, special manhole couplings, or shall be made in accordance with the manufacturer's recommendation. The floor of the manhole outside the channels shall be smooth and shall slope toward the channels not less than 1 inch per foot nor more than 2 inches per foot. Free drop inside the manholes shall not exceed 1 foot 6 inches, measured from the invert of the inlet pipe to the top of the floor of the manhole outside the channels, and drop manholes shall be constructed whenever the free drop would otherwise be greater than 1 foot 6 inches. Ladders shall not be installed unless the depth exceeds 12 feet.

6.2. **MANHOLE LADDER.** When the depth from top of cover to invert of main sewer exceeds 12 feet, manholes shall be provided with a straight type steel ladder not less than 16 inches in width with 7/8-inch-diameter rungs spaced 12 inches apart. The rails shall be not less than 2 inches by 1/2 inch in section. The ladder shall be adequately anchored to the wall by means of steel inserts spaced not more than 6 feet apart vertically and shall be so installed as to provide at least 6-1/2 inches of toe space between the wall and the inside of the rungs. The ladder and inserts shall be galvanized after fabrication in conformance with ASTM A 123. The wall along the line of the ladder shall be vertical for its entire height.

6.3. **JOINTING AND PLASTERING.** Mortar joints shall be completely filled and shall be smooth and free from surplus mortar on the inside of the manhole. Mortar and mastic joints between precast rings shall be full-bedded in jointing compound and shall be smoothed to a uniform surface on both the interior and exterior of the manhole. Installation of rubber gasket joints between precast rings shall be in accordance with the recommendations of the manufacturer.

6.4. **FRAMES AND COVERS.** Cast-iron frames and covers shall conform to Fed. Spec. RR-F-621, type I, size 24A frame with type A, size 24A cover. The frames and covers shall have a combined weight of not less than 400 pounds and shall conform to ASTM A 48, class 20B. The word "sewer", at least 2 inches high, shall be stamped or cast into all covers so as to be plainly visible. Unless otherwise shown on the drawings, the frames and covers shall be so set that the top of the cover will be flush with finished pavement grade or 2 inches higher than finished grade in unpaved areas.

7. **CONNECTIONS TO EXISTING MANHOLES.** Pipe connections to existing manholes shall be made in such manner that the finish work will conform to the essential applicable requirements specified for new manholes, including all necessary concrete work, cutting, and shaping. The bottom of existing manhole #103 shall be regrouted to allow a change in flow direction. The existing line shall be plugged and permanently sealed.

8. **BUILDING CONNECTIONS** shall include the lines to and connection with the building waste drainage piping at a point approximately 5 feet outside the building, unless otherwise indicated. Where building drain piping is not installed, the Contractor shall terminate the building connections approximately 5 feet from the site of the building at a point and in a manner designated by the Contracting Officer.

ZERO ACCIDENTS

SECTION 02724
FORCE MAINS; SEWER

INDEX

1. **APPLICABLE PUBLICATIONS.** The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

1.1. **AMERICAN NATIONAL STANDARDS INSTITUTE, INC. (ANSI) STANDARDS.**

A21.11-1980	Rubber Gasket Joints for Ductile-Iron and Gray-Iron Pressure Pipe and Fittings
B16.1-1975	Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250 and 800
B16.3-1985	Malleable Iron Threaded Fittings, Class 150 and 300

1.2. **AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) PUBLICATIONS.**

A 120-84a	Pipe, Steel, Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless, for Ordinary Uses
C 478-87	Precast Reinforced Concrete Manhole Sections
D 1785-86	Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
D 2122-85	Method of Determining Dimensions of Thermoplastic Pipe and Fittings
D 2146-82	Propylene Plastic Injection and Extrusion Materials
D 2241-87	Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR-Series)
D 2464-76	Threaded Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
D 2564-84	Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Pipe and Fittings
D 2657-87	Heat-Joining Polyolefin Pipe and Fittings
D 2774-72	Underground Installation of Thermoplastic Pressure Piping (R 1983)
D 2996-83	Filament-Wound Reinforced Thermosetting Resin Pipe
D 3035-85	Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Controlled Outside Diameter
D 3139-84	Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
D 3350-84	Polyethylene Plastics Pipe and Fittings Materials
D 3517-86	Fiberglass (Glass-Fiber-Reinforced Thermosetting-Resin) Pressure Pipe
F 477-76	Elastomeric Seals (Gaskets) for Joining Plastic Pipe (R 1985)

1.3. **AMERICAN WATER WORKS ASSOCIATION (AWWA) STANDARDS.**

C104-80	Cement-Mortar Lining for Ductile-Iron and Gray-Iron Pipe and Fittings for Water
C110-82	Ductile-Iron and Gray-Iron Fittings, 3-In. Through 48-In. for Water and Other Liquids

C115-83	Flanged Ductile-Iron and Gray-Iron Pipe With Threaded Flanges
C151-86	Ductile-Iron Pipe, Centrifugally Cast in Metal Molds on Sand-Lined Molds for Water or Other Liquids
C508-82	Swing-Check Valves for Waterworks Service 2-In. Through 24-In. NPS C600-82 Installation of Ductile-Iron Water Mains and Their Appurtenances
C603-78	Installation of Asbestos Cement Pressure Pipe
C900-81	Polyvinyl Chloride (PVC) Pressure Pipe, 4 In. & Erratum Through 12 In. for Water

1.4. THE MANUFACTURER'S STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS) PUBLICATION.

SP-78 Cast Iron Plug Valves, Flanges and Threaded Ends (1977)

2. **TESTING.** Testing shall be the responsibility of the Contractor. Testing shall be performed by an approved independent testing laboratory or by the Contractor subject to approval. The test may be witnessed by the Contracting Officer. The Contracting Officer shall be notified at least 7 days in advance of equipment tests. The final test report shall be delivered to the Contracting Officer within 30 days of the test.

3. **DELIVERY AND STORAGE.** All materials delivered and stored shall be handled and stored in such a manner that pipe, fittings and accessories, and pipe coatings are not damaged.

4. **EXCAVATION, TRENCHING, AND BACKFILLING FOR WATER LINES.** Excavation, trenching, and backfilling shall be in accordance with the applicable provisions of SECTION: EXCAVATION, TRENCHING, AND BACKFILLING FOR UTILITIES SYSTEMS except as modified herein.

5. **SUBMITTALS.** In accordance with SECTION: SPECIAL CLAUSES, the Contractor shall submit for approval, data as specified herein on the following:

5.1. CATEGORY I.

5.2. CATEGORY II. (For Information Only)
Manufacturer's Instructions (Para. 7)
Manufacturer's Data (Para. 7)
Hydrostatic Tests (Para. 8)
Final Test Reports (Para. 8)

6. **MATERIALS.**

6.1. PIPE AND FITTINGS.

6.1.1. General.

6.1.1.1. Buried piping shall be class 52 DIP ductile iron, manufactured according to AWWA C-151-76. Piping installed inside pump stations or valve vaults shall be ductile iron with bolted flanged joints.

6.1.1.2. All pipe, fittings, valves, and other force main appurtenances constructed of ductile cast-iron and installed below grade shall be provided with corrosion

protection as described in paragraph: Corrosion Protection, regardless of pipeline material.

6.1.2. Ductile Iron Pipe and Fittings.

6.1.2.1. Ductile Iron Pipe. AWWA C151, working pressure not less than 150 psi and a depth of bury of 5 feet unless otherwise shown or specified. Pipe shall be cement-mortar lined in accordance with AWWA C104. Linings shall be standard thickness. Provide rubber O-ring joints conforming to AWWA HI-67 in accordance with the manufacturer's recommendations.

6.1.2.2. Push-On Joints. ANSI A21.11.

6.1.2.3. Mechanical Joints. ANSI A21.11 as modified by AWWA C151.

6.1.2.4. Flanged Joints. AWWA C115.

6.1.2.5. Fittings, Mechanical. AWWA C110, rated for 150 psi.

6.1.2.6. Fittings, Push-On. AWWA C110 and ANSI A21.11, rated for 150 psi.

6.2. VALVES.

6.2.1. Check Valves. Check valves shall permit free flow of sewage forward and provide a positive check against backflow. Check valves shall be designed for a minimum working pressure of 150 psi or as indicated. The body shall be iron. Directly cast on the body shall be the manufacturer's name, initials, or trademark and also the size of the valve, working pressure, and direction of flow.

6.2.1.1. Ball Check Valves. Valves shall be iron body, shall have flanged ends, and shall be the non-slam type. Flanges shall be the 125-pound type complying with ANSI B16.1. Ball shall be stainless steel unless otherwise specified.

6.2.2. Plug Valves. MSS SP-78, non-lubricated type, regular pattern with resilient plug facing of Buna N, Hycar, or other material resistant to hydrocarbons. Valves installed in pump stations or valve vaults shall be provided with lever operators and position indicators. Buried valves shall be provided with operating nuts. All exposed bolts and nuts shall be zinc-plated or stainless steel.

6.2.3. Air Release Valves. Air release valves shall be designed to permit release of air from an empty pipe during filling and shall be capable of discharging accumulated air in the line while the line is in operation and under pressure. Valves shall be attached by means of threaded pipe connections. Valves shall be vented to the atmosphere. Automatic air release valves shall be used unless otherwise indicated.

6.2.3.1. Automatic Air Release Valve. Automatic air release valves shall be of the compound lever type capable of withstanding operating pressures of 150 psi. The valves shall have a 1/2-inch outlet. The body and cover of the valve shall be of iron with a stainless steel float. All internal parts shall be stainless steel or bronze. The valve shall be specifically adapted for use with sewage. Each

valve shall be complete with hose and blow-off valves to permit backflushing without dismantling the valve.

6.3. **VALVE BOXES.** Valve boxes shall be precast concrete manhole sections. The boxes shall be of such length as will be adapted, without full extension, to the depth of cover over the pipe at the valve locations. The word "Sewer" shall be cast in the cover.

6.4. **VALVE VAULTS.** Valve vaults shall be precast concrete units conforming to ASTM C 478 or cast-in-place as shown on the drawings. Concrete for cast-in-place structures shall conform to the SECTION: CONCRETE.

6.5. **MISCELLANEOUS MATERIALS.** Miscellaneous materials shall comply with the following requirements.

6.5.1. **Joint Lubricants.** Joint lubricants shall be as recommended by the pipe manufacturer.

6.5.2. **Bolts, Nuts and Glands.** ANSI A21.11.

6.5.3. **Bond Wire.** Type RHW or USE, Size 1/0 AWG, neoprene jacketed copper conductor shaped to stand clear of the joint.

6.6. **CORROSION PROTECTION** shall be provided for all buried ductile cast-iron piping, fittings, valves, and other force main appurtenances, regardless of pipe material. Corrosion protection shall consist of a cathodic protection system in accordance with SECTION: CATHODIC PROTECTION (GALVANIC ANODE TYPE) and a coating and/or wrapping system. The coating system may be of the fusion bonded epoxy coating or coal-tar epoxy types or other approved system. The coating system shall have a minimum dry coating thickness of 12 mils for fusion bonded epoxy or 22 mils for coal-tar epoxy types and other approved systems. Wrapping systems shall have a minimum thickness of 20 mils. Pipe primer shall be used when required. For highly irregular surfaces, fillers, putty, or coatings as recommended by tape manufacturer shall be used. Tape system shall be applied per manufacturer's recommendations. Polyethylene encasement shall not be used.

6.6.1. **Inspection of Coatings and/or Wrappings.** Any damage to the protective covering during transit and handling shall be repaired by the Contractor before installation. After field coating and wrapping has been applied, the entire pipe shall be inspected by an electric holiday detector with impressed current in accordance with NACE RP-02 using a full-ring, spring-type coil electrode. The holiday detector shall be equipped with a bell, buzzer, or other type of audible signal which sounds when a holiday is detected. All holidays in the protective covering shall be repaired immediately upon detection. Occasional checks of holiday detector potential will be made by the Contracting Officer to determine suitability of the detector.

7. **INSTALLATION.** All pipe, pipe fittings, and appurtenances installed at the locations indicated. Excavation, trenching, and backfilling shall be as specified in SECTION: EXCAVATION, TRENCHING AND BACKFILLING FOR UTILITIES SYSTEMS.

7.1. **UTILITY SEPARATION.** Pressure sewer pipe and water pipe shall be separated at least 10 feet horizontally. If conditions prevent 10 feet separation, a minimum of 6 feet horizontal distance shall be provided along with a minimum vertical separation of 12 inches from the bottom of the water pipe to the top of the pressure sewer pipe. Where pressure sewer pipe must cross water pipe, pressure sewer pipe shall always cross beneath water pipe. A vertical distance of 2 feet between the bottom of water pipe and the top of pressure

sewer pipe shall be maintained. The force main joints shall not be closer than 3 feet horizontally to the point of crossing.

7.2. **CUTTING.** Pipe shall be cut in a neat manner with mechanical cutters. Wheel cutters shall be used where practicable. Sharp and rough edges shall be ground smooth and loose material removed from the pipe before laying except as otherwise specified.

7.3. **LAYING.** Except where authorized, pipe shall be laid with bells facing the direction of laying. Before lowering and while suspended, the pipe shall be inspected for defects. Defective material shall be rejected. Pipe shall be laid in compliance with the following:

7.3.1. **Ductile Iron.** AWWA C600.

7.4. **JOINTING.**

7.4.1. **Ductile Iron Pipe.** Installation of mechanical and push-on type joints shall comply with AWWA C600 and the manufacturer's instructions. Installation of flanged joints shall comply with manufacturer's instructions. Flanged joints shall be used only inside of structures.

7.5. **VALVES.** Prior to installation, valves shall be cleaned of all foreign matter and inspected for damage. Valves shall be fully opened and closed to insure that all parts are properly operating. Valves shall be installed with the stem in the vertical position. [Valves shall be installed in valve vaults as indicated.]

7.6. **VALVE BOXES.** Valve boxes shall be installed over each outside valve, unless otherwise indicated. Valve boxes shall be centered over the valve. Fill shall be carefully tamped around each valve box to a distance of 4 feet on all sides or to undisturbed trench face, if less than 4 feet.

7.7. **VALVE VAULTS.** Valve vaults shall be installed as indicated.

7.8. **DRAIN LINES.** Drain lines shall be installed where indicated. The drain line shall consist of a tee in the main line with a 4-inch diameter branch, a 4-inch diameter elbow, and a 4-inch plug valve.

7.9. **BONDED JOINTS.** For ferrous piping, a metallic bond shall be provided at each joint, including joints made with flexible couplings, caulking or rubber gaskets, of ferrous-metallic piping to effect continuous conductivity. The bond shall be of the thermal weld type. Test leads shall be provided in accordance with the details shown on the drawings. Test leads shall be placed at intervals not exceeding 1,000 feet, on pipe casings, and where the pipe crosses within 6 inches of any other metal pipe (provide 2 test leads, one each pipe). Test leads will not be required within 300 feet of a riser pipe or any other place where the pipe may be readily accessible. The Contractor shall provide a plan showing dimensioned location of all test leads. Test leads and bond connections shall be made with the exothermic weld process, insulated with coal tar base mastic and protected with a weld shield or a plastic weld cap.

8. **HYDROSTATIC TESTS.** The pipeline shall be subjected to both a pressure test and a leakage test.

8.1. **PRESSURE TEST.** After the pipe has been installed, joints completed, thrust blocks have been in place for at lest 5 days, and the trench has been partially backfilled, leaving the joints exposed for examination, the pipe shall be filled with water in a manner to expel all air. The pipeline shall be subjected to a test pressure of 100 psi or 150 percent of the working pressure, whichever is greater, for a period of at least 1 hour. Each valve shall be opened and closed several

times during the test. The exposed pipe, joints, fitting, and valves shall be examined for leaks. Visible leaks shall be stopped or the defective pipe, fitting, joints, or valve shall be replaced.

8.2. **LEAKAGE TEST.**

8.2.1. The leakage test may be conducted subsequent to or con- currently with the pressure test.

8.2.2. The amount of water permitted as leakage for the line shall be placed in a sealed container attached to the supply side of the test pump. No other source of supply will be permitted to be applied to the pump or line under test. The water shall be pumped into the line by the test pump as required to maintain the specified test pressure as described for pressure test for a 2-hour period. Exhaustion of the supply or the inability to maintain the required pressure will be considered test failure.

8.2.3. Leakage considered acceptable shall be less than the number of gallons per hour as determined by the following formula:

$L = ND\ P/K$ Where:
L = Allowable leakage in gallons per hour.
N = Number of joints in length of pipeline tested.
D = Nominal diameter of the pipe in inches.
P = Square root of the test pressure in psig.
K = 7400 for other pipe materials.

8.2.4. At the conclusion of the test, the amount of water remaining in the container shall be measured and the results recorded in the test report.

8.3. **RETESTING.** If any deficiencies are revealed during any test, such deficiencies shall be corrected and the tests shall be reconducted until the results of the tests are within specified allowances without additional cost to the Government.

ZERO ACCIDENTS

SECTION 05500
MISCELLANEOUS METAL

INDEX

1. **APPLICABLE PUBLICATIONS.** The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

1.1. FEDERAL SPECIFICATIONS.

L-S-125B	Screening, Insect, Nonmetallic
FF-S-85C & Am-1	Screw, Cap, Slotted and Hexagon Head
FF-S-92B & AM-1	Screw, Machine: Slotted, Cross-Recessed or Hexagon Head
FF-S-111D	Screw, Wood
FF-S-325 & Int. Am-3 (GSA-FSS)	Shield, Expansion; Nail, Expansion; and Nail, Drive Screw (Devices, Anchoring, Masonry)
FF-W-84a & Am-3	Washers, Lock (Spring)
QQ-F-461c & Am-1	Floor Plate, Steel, Rolled
QQ-S-763E	Steel Bars, Wire, Shapes, and Forgings, Corrosion-Resisting
QQ-S-766c & Int. Am-6	Steel Plates, Sheets, and Strip - Corrosion Resisting
RR-G-661D	Grating, Metal, Bar Type (Floor, Except for Naval Vessels)

RR-G-661D	Grating, Metal, Bar Type (Floor, Except for Naval Vessels)
RR-G-1602B	Grating, Metal, Other Than Bar Type (Floor, Except for Naval Vessels)
RR-S-001301 (FAA)	Safety Equipment, Climbing
RR-W-365A & Int. Am-1	Fabric (Insect Screening)
TT-V-51F	Varnish; Asphalt

1.2. **MILITARY SPECIFICATIONS.**

MIL-M-17194D	Metal, Expanded, Steel
MIL-C-18480B	Coating Compound, Bituminous, Solvent, Coal Tar Base

1.3. **AMERICAN INSURANCE ASSOCIATION (AIA) PUBLICATION.**
National Building Code (1976; Amendments Dec 1977)

1.4. **AMERICAN NATIONAL STANDARDS INSTITUTE, INC. (ANSI) STANDARD.**

A 14.3-1984	Safety Requirements for Fixed Ladders

1.5. **AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) STANDARDS.**

A 36-84a	Structural Steel
A 48-83	Gray Iron Castings
A 53-86	Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

1.6. **AMERICAN WELDING SOCIETY (AWS) STANDARD.**

D1.1-86	Structural Welding Code - Steel

1.7. **NATIONAL FIRE PROTECTION ASSOCIATION (NFPA) STANDARDS.**

No. 101-1985	Code for Safety to Life from Fire in Buildings and Structures
No. 211-1984	Chimneys, Fireplaces, Vents, and Solid Fuel Burning Appliances

1.8. **WOVEN WIRE PRODUCTS ASSOCIATION (WWPA) PUBLICATION.**
Woven Wire: Protection and Security (1977)

2. **GENERAL.** The following general requirements shall apply to all miscellaneous metal items unless otherwise noted or specified.

2.1. **FABRICATION.** The Contractor shall verify all dimensions and shall take necessary field measurements before fabrication. Design and fabrication details of all items shall be such as to provide adequate strength and stiffness.

2.2. **SIZES AND GAGE** shall be no smaller or lighter than those specified hereinafter, but slightly larger or heavier sizes and gages will generally be acceptable. Gages of materials shall be manufacturers standard gage.

2.3. **GALVANIZING.** Items specified to be galvanized shall be hot-dip processed after fabrication. Galvanizing shall be in accordance with ASTM A 123, A 386, or A 525, as applicable.

2.4. **FASTENERS.** All exposed-to-view fasteners shall generally match in color and finish, and shall harmonize with the material to which fasteners are applied.

2.5. **COMPLETENESS.** Materials, parts, bolts, anchors, supports, braces, and connections necessary for completion of the work shall be provided even though not precisely shown or specified. The necessary rebates, lugs and brackets shall be provided so that the work can be assembled in a neat and rigid manner.

2.6. **INSTALLATION.** Holes for bolts and screws shall be drilled or neatly punched. Poor matching of holes shall be cause for rejection of the work. Fastenings shall be concealed where practicable. Assembly and installation shall provide ample strength to completed installation. Joints exposed to the weather shall be formed to exclude water.

2.7. **CORROSION PROTECTION - DISSIMILAR MATERIALS.** Contact surfaces between dissimilar metals and aluminum surfaces in contact with concrete, masonry, pressure-treated wood or absorptive materials subject to wetting, shall be given a protective coating conforming to Military Specification MIL-C-18480 or to Fed. Spec. TT-V-51.

3. **MATERIALS** shall conform to the requirements specified for the particular item; and where these requirements are not specified in detail, the materials shall be suitable for the intended usage of the item.

3.1. **ANCHORS.**

3.1.1. **Expansion Shields.** Fed. Spec. FF-S-325.

3.1.2. **Toggle Bolts.** Fed. Spec. FF-B-588.

3.2. **EXPANDED METAL** shall conform to Military Specification MIL-M-17194, type II, class 1 or class 2.

3.3. **FASTENERS.**

3.3.1. **Bolts and Nuts** shall be suitable for use intended.

3.3.2. **Powder-Driven Fasteners** may be used only when approved in writing.

3.3.3. **Screws.** Fed. Spec. FF-S-85, FF-S-92, and FF-S-111, as best suited for use intended.

3.3.4. **Washers.** Fed. Spec. FF-W-84 for lock washers. Flat washers shall be suitable for use intended.

3.4. **FLOOR PLATE, RAISED TREAD.** Fed. Spec. QQ-F-461, class 1, pattern to be selected by the Contracting Officer.

3.5. **HARDWARE.** Unless otherwise specified, hardware provided as an integral part of miscellaneous metal shall conform to applicable ANSI Standard.

3.6. **INSECT SCREEN.** Fed. Spec. RR-W-365, Type II, III, or VII, 18 by 16 mesh, or Fed. Spec. L-S-125, type II, bronze or aluminum color, 18 by 16 mesh.

3.7. **WOVEN WIRE** for partitions and guards shall conform to Woven Wire: Protection and Security published by the Woven Wire Products Association.

4. **SUBMITTALS.** In accordance with SECTION: SPECIAL CLAUSES, the Contractor shall submit the following:

4.1. **CATEGORY I for approval.**

4.1.1. Manufacturer's descriptive data as follows:
Access doors and access panels (Para. 9)
Handrails (Para. 24)
Ladder safety device (Para. 27)
Steel stairs (Para. 40)

4.2. **CATEGORY II** for information only.

4.2.1. Certification for ladder safety device. (Para. 27)

4.3 **CATEGORY III** for review and approval.

4.3.1 Shop and fabrication drawings as follows:
Support pipe
Rail supports
Hatch lids
Weather proof cabinets

5. **NOT USED.**

6. **WORKMANSHIP.** Miscellaneous metalwork shall be formed to correct shapes and sizes with sharp lines, angles, true curves, and finish all in accordance with approved shop drawings and samples. Drilling and punching shall produce clean true lines and surfaces. All items shall be accurately set to established lines and elevations and securely fastened in place.

6.1. **WELDING** shall be in accordance with AWS D1.1. Welding shall be continuous along the entire area of contact except where tack welding is permitted. Connections to be exposed after installation shall be continuous welded. Exposed welds shall be ground smooth.

6.2. **EXPOSED SURFACES** of work in place shall have a smooth finish, and unless otherwise approved, exposed riveting shall be flush.

6.3. **JOINTS** where tight fits are required shall be milled to a close fit. Corner joints shall be coped or mitered, well formed, and in true alinement.

7. **QUALIFICATION OF WELDERS.** Welding to or on structural steel or miscellaneous items of structural steel such as lintels and ladders shall be performed by certified welders qualified in accordance with procedures covered in AWS D1.1 using procedures and materials and equipment of the type required for the work.

8. **ANCHORAGE** shall be provided where necessary for fastening miscellaneous metal items securely in place. Anchorage not otherwise specified shall include slotted inserts, expansion shields. Powder-driven fasteners shall not be used. Toggle bolts and through bolts for masonry; machine and carriage bolts for steel; through bolts, lag bolts, and screws for wood. Slotted inserts shall be of types required to engage with the anchors and shall be approved.

9. **ACCESS DOORS AND ACCESS PANELS** shall be flush type unless otherwise indicated. Frames for access doors shall be fabricated of not lighter than 16-gage steel with welded joints and anchorage for securing into construction. Access door and panels shall be a minimum of not lighter than 14-gage steel. Access doors shall be 16 by 20 inches with stiffened edges and welded attachments and shall be hinged to frame and provided with a flush-face turn-screw-operated latch. [Access doors in fire rated

walls and ceilings shall be of equivalent fire rating.] One access panel shall be provided and installed directly below each valve, flow indicator, damper, or air splitter that would otherwise not be accessible, and is located above the ceiling, except for suspended removable-panel-type ceilings. Manufacturer's descriptive catalog data shall be submitted.

10. **NOT USED.**

11. **NOT USED.**

12. **NOT USED.**

13. **NOT USED.**

14. **CORNER GUARDS AND SHIELDS** for jambs and sills of openings and edges of platforms shall be steel shapes and plates anchored in masonry or concrete with welded steel straps or end-weld stud anchors. Corner guards for use with glazed or ceramic tile finish on walls shall be formed of 0.0625-inch thick corrosion-resisting steel, Fed. Spec. QQ-S-766, class 430 with polished or satin finish, shall extend 5 feet above the top of cove base or to the top of the wainscot, whichever is less, and shall be anchored with adjustable anchors of 16-gage expanded metal.

15. **STRUCTURAL STEEL DOORFRAMES** shall be neatly mitered and welded at the corners with all welds ground smooth. Jambs shall be provided with 2- by 1/4- by 12-inch bent metal adjustable anchors spaced not over 2 feet 6 inches on centers. The bottom of the frames shall be secured to the slab by means of angle clips and expansion bolts. Stops shall be made of 1-1/2- by 5/8-inch bars welded or top-screwed to the frame on not more than 18-inch centers. Screws shall be countersunk. Stops shall be attached to provide full continuous contact with the frame. Head members spanning more than 3 feet shall be reinforced. Necessary reinforcements shall be made. Frames shall be drilled and tapped to receive the hardware.

16. **NOT USED.**

17. **NOT USED.**

18. **NOT USED.**

19. **NOT USED.**

20. **FLOOR GRATINGS AND FRAMES.** Floor gratings shall be designed to support a live load of 100 pounds per square foot for the spans indicated, and unless otherwise indicated shall conform to Fed. Spec. RR-G-661 or RR-G-1602. Edges of bar type gratings shall be banded with bars 1/8 inch less in depth than the bearing bars. Banding bars shall be flush with top of bearing bars. Frames of steel shapes and all-welded construction finished to match grating shall be provided as indicated. [Frames shall be provided with welded-on anchors.] [Frames shall be anchored to structural members with bolts, toggle bolts, or expansion shields and bolts.] [Floor gratings and frames shall be galvanized.]

21. **FLOOR PLATES** of patterned steel plate 1/4 inch thick shall be provided in dimensions and arrangements indicated.

22. **NOT USED.**

23. **NOT USED.**

24. **HANDRAILS.** Manufacturer's descriptive data shall be submitted.

24.1. **STEEL RAILINGS** including pipe inserts in concrete shall be standard-weight steel pipe conforming to ASTM A 53. Pipe shall be 2-inch size.

24.1.1. **Fabrication.** Jointing of post, rail, and corners shall be by one of the following methods:

24.1.1.1. Flush-type rail fittings of commercial standard, welded and ground smooth with railing splice locks secured with 3/8-inch hexagonal-recessed-head setscrews.

24.1.1.2. Mitered and welded joints made by fitting post to top rail and intermediate rail to post, mitering corners, groove welding joints, and grinding smooth. Railing splices shall be butted and reinforced by a tight-fitting interior sleeve not less than 6 inches long.

24.1.1.3. Railings may be bent at corners in lieu of jointing, provided bends are made in suitable jigs and that the pipe is not crushed.

24.1.2. **Installation.**

24.1.2.1. **In Concrete.** Rails shall be installed by means of steel pipe sleeve inserts set and anchored in the concrete as indicated. Posts shall be inserted into the steel pipe sleeves, leveled, plumbed, and aligned. The annular space between pipe posts and pipe sleeve inserts shall be filled solid with molten lead or sulphur or a quick-setting hydraulic cement. Anchorage joint shall be covered with pipe collar pinned to post. Ends of rails shall be secured by means of standard steel pipe flange anchored to concrete walls by expansion shields and bolts.

24.1.2.2. **In Steel.** Rails shall be installed by means of base plates bolted to stringers or structural framework.

24.1.3. **Removable Sections** shall be furnished as indicated.

25. **LADDERS** shall be steel fixed-rail type conforming to ANSI A14.3. Rungs shall be 3/4-inch solid-steel rods, fitted into punched holes in rails, welded, and ground smooth. All splices and connections shall have a smooth transition with original members without projections that are sharp or more extensive than required for joint strength. Rails shall be fitted with brackets at the spacing indicated for anchorage to structure.

26. **INDIVIDUAL-RUNG LADDER** shall conform to ANSI A14.3 and rungs shall be bent from 1-inch round solid steel rods, hot-dip zinc-coated after forming. Rungs shall be so shaped that the crossbar will be at least 3 inches below the horizontal plane of the side bars to prevent the foot from slipping off the rung. Individual bent steel rungs

shall be spaced not over 12 inches on center and shall be anchored directly into concrete or masonry wall. Center of rung shall be 7 inches clear of wall. They shall be set in true alinement and projection to surface.

27. **NOT USED.**

28. **NOT USED.**

29. **METAL NOSING FOR DOOR SILLS AND CURBS.** Protective metal nosings for exposed concrete edges or corners shall be formed from a single section of iron or aluminum castings.

30. **NOT USED.**

31. **MISCELLANEOUS PLATES AND SHAPES** lintels, sill angles, equipment mountings, and frames, shall be provided to complete the work. Miscellaneous plates and shapes shall conform to ASTM A 36.

32. **NOT USED.**

33. **NOT USED.**

34. **NOT USED.**

35. **NOT USED.**

36. **SAFETY CHAINS AND GUARDRAILS.** Safety chains shall be constructed of galvanized wrought iron. Chains shall be straight link style, 3/16-inch diameter, with at least twelve links per foot, and with snap hooks on each end. Snap hooks shall be boat type and eye bolts for attachment of chains shall be galvanized 3/8-inch bolt with 3/4-inch eye diameter, anchored as indicated. Two chains 4 inches longer than the anchorage spacing shall be supplied for each guarded area. The top chain or guardrail shall be mounted 3 feet 6 inches above the floor and the lower chain or rail shall be mounted 2 feet above the floor.

37. **SAFETY NOSINGS** shall be of cast iron with plain abrasive surface. Nosing shall be 3 inches wide and terminating at not more than 6 inches from the ends of treads, except nosing for metal-pan cement-filled treads shall extend the full length of the tread. Safety nosings shall be provided with integrally cast anchors for embedding into concrete and shall be flush with the top of the traffic surface.

38. **NOT USED.**

39. **NOT USED.**

40. **NOT USED.**

41. **NOT USED.**

42. **NOT USED.**

43. **NOT USED.**

44. **NOT USED.**

45. **VAULT VENTS** shall be galvanized-steel-pipe, as indicated. Screen and fittings shall be type standard with the manufacturer.

46. **NOT USED.**

46A. **PIPE GUARDS** shall be standard-weight pipe filled with concrete, rounded above top, 2 feet 6 inches minimum above slab.

47. **NOT USED.**

48. **NOT USED.**

49. **NOT USED.**

50. **NOT USED.**

51. **NOT USED.**

52. **NOT USED.**

53. **SHOP PAINTING.** Surfaces of ferrous metal, except galvanized surfaces, shall be cleaned and shop coated with the manufacturer's standard protective coating. Bituminous primer, if used, shall conform to Fed. Spec. TT-V-51 or to Military Specification MIL-C-18480, but items to be finish painted shall be coated with other than a bituminous protective coating. Prior to shop painting surfaces shall be cleaned with solvents to remove grease and oil and with power wire-brushing or sandblasting to remove loose rust, loose mill scale, and other foreign substances. Surfaces of items to be embedded in concrete shall not be shop painted.

ZERO ACCIDENTS

SECTION 03303
CONCRETE

INDEX

1. **APPLICABLE PUBLICATIONS.** The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

1.1 **AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) PUBLICATIONS.**

A 185-85	Steel Welded Wire Fabric, Plain, for Concrete Reinforcement
A 615-87	Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
C 33-86	Concrete Aggregates
C 94-86b	Ready-Mixed Concrete
C 150-86	Portland Cement
C 231-87	Air Content of Freshly Mixed Concrete by the Pressure Method

1.2 **AMERICAN CONCRETE INSTITUTE (ACI) STANDARD.**

ACI 301-1984	Specifications for Structural Concrete for Buildings

2. **GENERAL.** Concrete construction covered by this section consists of all required concrete construction (except pavement slabs). Concrete shall be an approved mixture of portland cement, water, fine and coarse aggregate. The mixture shall be proportioned for a minimum cement content of 564 pounds per cubic yard, and shall have a minimum compressive strength of 3000 psi at 28 days. The concrete shall have a slump between 2 and 4 inches. An approved air-entraining admixture shall be batched in the mixture in proper proportions to produce a total air content between 4 and 7 percent of the volume of the concrete when determined in accordance with the requirements of ASTM C 231. This mixture shall be used for all concrete referenced hereto from other sections regardless of the class of concrete referenced.

3. **MATERIALS.**

3.1 **CEMENT.** Cement shall be Portland cement conforming to the requirements of ASTM C 150, Type I or II, low alkali.

3.2 **AGGREGATES.** Fine and coarse aggregates shall conform to the requirements of ASTM C 33. Maximum size of coarse aggregate shall be 3/4-inch.

3.3 **WATER** shall be potable water.

3.4 **REINFORCING.** Reinforcing steel shall conform to the requirements of ASTM A 615, Grade 60. No welding shall be performed on reinforcing steel. Welded wire fabric shall conform to the requirements of ASTM A 185.

4. **CONCRETING OPERATIONS.** Batching, mixing, conveying, placing, forming, finishing, curing and protection of concrete, and placing of reinforcement shall conform to the requirements of American Concrete Institute Standard "Specifications for Structural Concrete for Buildings," ACI-301, and shall be subject to approval, except that all concrete shall be consolidated with mechanical internal vibrators and that only floated, troweled, or broomed finish, as directed, will be required for unformed surfaces. Ready-mixed concrete, if used, shall conform to the requirements of ASTM C 94.

5. **CONTRACTOR'S QUALITY CONTROL.** Quality control sampling and testing shall be performed by the Contractor in accordance with paragraph: CONTRACTOR QUALITY CONTROL in SECTION: SPECIAL CLAUSES and as specified herein. The Government may perform verification tests as considered necessary but this will in no way relieve the Contractor of his quality control sampling and testing responsibility.

ZERO ACCIDENTS

SECTION 11303
GUIDE-MOUNTED SEWAGE LIFT STATIONS

INDEX

1. **APPLICABLE PUBLICATIONS.** The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

1.1. AMERICAN NATIONAL STANDARDS INSTITUTE, INC. (ANSI) STANDARDS.

A21.51-1981 & Erratum	Ductile-Iron Pipe, Centrifugally Cast in Metal Molds or Sand-Lined Molds, for Water and Other Liquids
B16.1-1975	Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800

1.2. AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) STANDARDS.

A 120-84	Pipe, Steel, Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless, for Ordinary Uses
A 153-82	Zinc Coating (Hot-Dip) on Iron and Steel Hardware
C 478-87	Precast Reinforced Concrete Manhole Sections
C 890-78 (R 1985)	Minimum Structural Design Loading for Monolithic on Sectional Precast Concrete Water and Wastewater Structures

1.3. AMERICAN WATER WORKS ASSOCIATION (AWWA) STANDARD.

C 207-86	Steel Pipe Flanges for Waterwork Service - Sizes 4 In. Through 144 In.

1.4. ANTI-FRICTION BEARING MANUFACTURERS ASSOCIATION (AFBMA) STANDARDS.

STD 9-1978	Load Ratings and Fatigue Life for Ball Bearings
STD 11-1978	Load Ratings and Fatigue Life for Roller Bearings

1.5. HYDRAULIC INSTITUTE (HI) PUBLICATION.

Hydraulic Institute Standards for Centrifugal, Rotary and Reciprocating Pumps (14th Edition, 1983)

1.6. MANUFACTURER'S STANDARDIZATION SOCIETY OF VALVE AND FITTINGS INDUSTRY (MSS) PUBLICATION.

SP-78	Cast Iron Plug Valves, Flanged, and Threaded Ends (1977)

1.7. NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA) STANDARD.

MG-1-1978	Motors and Generators Incl Rev 1 thru 8

1.8. **NATIONAL FIRE PROTECTION ASSOCIATION (NFPA) PUBLICATION.**
No. 70-1987 National Electrical Code

2. **GENERAL.** This section includes guide-mounted submersible sewage pumps, motors, duplex control panel alternator level switches, guide rails and supports, piping, valve chamber, pump chamber and accessories.

2.1. **STANDARD PRODUCTS.** Material and equipment to be provided shall be the standard catalog product of a manufacturer regularly engaged in the manufacture of the product and shall essentially duplicate material and equipment that have been in satisfactory use at least 2 years prior to bid opening.

2.2. **NAMEPLATES.** Each major component of equipment shall have the manufacturer's name, address, catalog or model number, rated power, and electrical requirements on a plate securely attached to the item of equipment.

2.3. **VERIFICATION OF DIMENSIONS.** The Contractor shall become familiar with all details of the work, verify all dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing the work.

2.4. **FACTORY TESTS.** Pumps shall be tested by the manufacturer or a nationally recognized testing agency in compliance with Hydraulic Institute Standards. Where two or more identical pumps are specified, only one representative pump shall be tested. Certified test results shall be submitted to the Contracting Officer.

3. **SUBMITTALS.** In accordance with SECTION: SPECIAL CLAUSES, the Contractor shall submit for approval, items as listed in the following categories:

3.1. **CATEGORY I.**
Valves and Piping
Sewage Pumps
Motor Controls
Motors
Station Structure
Access Covers
Pump Characteristic Curves clearly shows the following information on the pump characteristic curves:
- Head-capacity curve
- Efficiency curve
- NPSH curve
- BHP curve
- Shut off head
- Maximum capacity at which pump can operate continuously with out cavitation
- Minimum capacity at which pump can operate continuously without overheating

Wiring Diagrams

3.2. **CATEGORY II.**
Field Test Results
Spare parts data

3.2.1. **For Approval.**
Operating and Maintenance Instructions (Para. 13.2)

4. **MATERIALS AND EQUIPMENT.** The following materials and equipment shall conform to the respective publications and other requirements specified below.

4.1. **CHECK VALVES.**

4.1.1. **Horizontal Swing Type Check Valves** shall be installed in pump discharge lines and shall be suitable for handling domestic sewage. Valve shall permit free flow of sewage forward and provide a positive check against backflow. Body shall be iron with a removable cover for inspection and removal of the gate assembly. Gate, gate seat, gate studs and nuts shall be bronze or other suitable alloy.

4.1.2. **Ball Check Valves,** suitable for handling domestic sewage, are acceptable for installation in pump discharge lines 2 inches and smaller when recommended by the pump manufacturer. The valve shall be the non-slam type designed to permit free flow of sewage forward and a positive check against backflow. Valve shall have a cast-iron body with a renewable rubber seat. Ball shall be stainless steel unless otherwise indicated. All screws, nuts, and bolts shall be of stainless steel or other corrosion-resistant materials.

4.2. **PLUG VALVES** shall conform to MSS SP-78 and to the following:
Type - Nonlubricated
Pattern - Regular
Plug - Resilient facing resistant to hydrocarbons. Hycar or Buna N
Operator - Lever with position indicator
Exposed Bolts and Nuts - Zinc plated or stainless steel

4.3. **PIPE.**

4.3.1. **Ductile Iron.** ANSI A21.51, thickness class 53 with ANSI B16.1 class 125 flanges.

4.3.2. **Steel Pipe.** ASTM A 120, standard weight. Steel pipe shall not be installed in contact with earth.

4.3.3. **Plastic Pipe.** Plastic pipe shall not be installed within the pump chamber or the valve chamber. PVC pipe installed between the pump chamber and valve chamber shall conform to specification SECTION: FORCE MAINS; SEWER.

4.4. **JOINTS.**

4.4.1. **Ductile Iron.** Joints and fittings shall conform to ANSI B16.1, class 125.

4.4.2. **Steel.** Flanges shall conform to AWWA C207, Class D.

5. **ELECTRICAL WORK.** Motors, manual or automatic motor control equipment and protective or signal devices required for operation specified herein and any wiring required therefor, but not shown on the electrical plans, shall be provided under this section in accordance with SECTION: ELECTRICAL WORK, INTERIOR. All wiring and disconnect switches installed within the pump basin shall be suitable for class I, division I locations.

6. **SEWAGE PUMPS.**

6.1. **GENERAL.**

6.1.1. **Guide-Mounted Submersible Grinder Pumps.** Pumps shall be of the centrifugal type with an integrally built-in grinder unit and submersible motor. Each pump, when operating under conditions of the specified capacities and head, shall be as near the peak efficiency as practicable.

6.2. **PUMP CHARACTERISTICS.** Pumps shall have the following operating characteristics:

6.2.1. **Furnish pumps** manufactured by Hydromatic or approved equal Heavy-duty grinder, submersible unit.

6.2.2. **Capacity 45 gpm at 50 feet total dynamic head.**

6.2.3. **Minimum motor rating: 5 HP.**

6.2.4. **2" Discharge**

6.2.5. **Power 200/230/460**

6.2.6. **Hydromatic model SPGF500/GZFX500 or preapproved equal**

6.2.7. **Provide check valves and gate values per pump manufacturer's recommendations**

6.3. CONTROLS.

6.3.1. **Controller.** The pump controller shall be mounted in NEMA 4X general-purpose stainless steel enclosures. The controls shall automatically alternate the lead pump between circles. The controls shall be suitable for two sequences of pump operations, which can be alternated by manual setting, as follows:

6.3.2. **Floats.** Sealed float-type mercury switches shall be provided to control sump levels and provide an alarm signal. Mercury switches shall be sealed in an inert synthetic casing suspended in the sump and held in place as detailed on the drawings. Three floats shall be provided for level control and one for alarm control.

6.3.3. **Alarm.** An alarm light and audible alarm in a weatherproof enclosure shall be provided at the control box actuated by a high liquid level in the pump chamber. The audible alarm shall be equipped with a silencing switch with automatic reset.

6.3.4. **Operation.** On a rising liquid level, the lead pump shall be started when the liquid level reaches float number 2. When the liquid level reaches float number 3, the lag pump shall start and operate in conjunction with the lead pump. Both pumps shall operate until the liquid level falls to float number 1 (lowest). When the liquid level reaches float number 4, the alarm light and bell shall be actuated, indicating a high liquid level. Float switch number 1 will stop pump operation. A mechanical or electrical automatic alternator shall be provided to transpose the starting sequence of the lead pump.

7. PUMP CONSTRUCTION.

7.1. **POWER CABLE.**

7.1.1. The power cable shall comply with NFPA No. 70, Type SO, and shall be of standard construction for submersible pump applications sized according to NEC standards.

7.1.2. The power cable shall enter the pump through a heavy-duty entry assembly provided with an internal grommet assembly to prevent leakage. The cable entry junction chamber and motor shall be separated by a stator lead sealing gland or terminal board which shall isolate the motor interior from foreign material gaining access through the pump top. Epoxies, silicones, or other secondary sealing systems are not acceptable.

7.1.3. The power and control cables shall be run continuously between controller and pumps.

7.2. **SEALING FLANGE.** Each pump shall be equipped with a sliding guide bracket which will mate to the pump discharge elbow when the pump is lowered into position. Connection shall be made in such a manner to provide a leakless seal without the use of bolts and nuts and without personnel entering the pump pit.

7.3. **GRINDER ASSEMBLY.** The grinder assembly shall consist of a hardened stainless steel renewable cutter ring and cutter impeller. The assembly shall be designed to shear and reduce all materials normally found in domestic sewage such as wood, plastic, and rags into a fine slurry. The slurry shall be capable of passing through 2-inch diameter piping system including check and valves.

8. MISCELLANEOUS.

8.1. RAIL-MOUNTED SYSTEMS.

8.1.1. **Rail Mounted System for Grinder Pumps.** Rail mounted installation systems shall consist of galvanized guide rails, a sliding bracket and a sealing flange. Guide rails shall be of the size and type standard with the manufacturer and shall not support any portion of the weight of the pump. Guide rails shall be anchored at the top and bottom of the basin with intermediate supports provided if wet well depth exceeds 12 feet. The sliding guide bracket shall be an integral part of the pump unit. The sealing flange shall be permanently installed in the wet well along with the discharge piping. The check valve shall be located between the pump discharge and the sealing flange such that the check valve is removed with the grinder pump as an assembly. The pump shall be automatically connected to the sealing flange when lowered into place and shall be easily removed for inspection and service without entering the pump chamber.

8.1.2. **Lifting Chain.** Lifting chain to raise and lower the pump through the limits indicated shall be provided. The chain shall be galvanized and shall be capable of supporting the pump.

8.2. PUMP AND VALVE CHAMBERS.

8.2.1. **Concrete.** Pump chamber shall be constructed of precast manhole sections conforming to ASTM C 478. Valve chambers may be of precast concrete manhole sections conforming to ASTM C 478, precast concrete designed in accordance with ASTM C 890, or poured-in-place concrete as detailed on the drawings with 3,000 psi concrete. The top and bottom slabs shall be constructed as detailed on the drawings. Concrete shall conform to the SECTION: CONCRETE.

8.3. **ACCESS FRAMES AND DOORS.** Access doors and curb frames shall be provided complete with interior snap lock, removable key wrench, cast steel hinges, and locking bar. Doors shall lock in the open 90 Degrees position. Doors shall be of aluminum plate construction with non-slip diamond pattern rated for a live load of 150 pounds per square foot. Bituminous coating shall be applied to the exterior of the frame.

8.4. **LABELS.** All switches, lights, horns, controls, etc., shall be clearly identified with permanent labels or tags. The labels shall be plastic or metal and shall be permanently attached.

9. **MISCELLANEOUS METAL.** Bolts, nuts, anchors, washers, and all other types of supports necessary for the installation of the equipment shall be furnished and shall be of steel galvanized according to ASTM A 153.

10. **SPECIAL TOOLS** necessary for the proper operation and maintenance of the equipment, including one pressure gun for each type of grease required, shall be furnished in a hardwood or metal container.

11. **ACCEPTANCE TESTS.** The Contractor shall furnish the manufacturer's report of pump capacity determined by shop tests and make such tests as may be necessary to verify the pump capacity. Tests shall assure that all equipment, including the pump, have been installed in accordance with the specifications. Tests shall assume that pumps, controls, and fittings, as installed, are operating as specified.

12. **PUMP CHARACTERISTIC CURVES,** properly identified and prepared by the pump manufacturer showing capacities, heads, efficiencies, and brake horsepower throughout the entire range of the pump, shall be furnished.

13. **OPERATING AND MAINTENANCE INSTRUCTIONS AND SPARE-PARTS DATA.**

13.1. **SPARE-PARTS DATA.** The Contractor shall furnish spare-parts data for each different item of materials and equipment specified. The data shall include a complete list of parts and supplies, with current unit prices and source of supply.

13.2. **OPERATING AND MAINTENANCE INSTRUCTIONS.**

13.2.1. Operating instructions outlining the step-by-step procedures required for system start-up and operation shall be furnished. The instructions shall include the manufacturer's name, model number, service manual, parts list, and brief description of all equipment and their basic operating features.

13.2.2. Maintenance instructions listing routine maintenance procedures and possible breakdowns and repairs shall be furnished. The instructions shall include simplified diagrams for the system as installed.

13.2.3. Contractor shall conduct a training course for operating staff as designated by the Contracting Officer. The training period shall start after the system is functionally completed but prior to final acceptance tests. The field instructions shall cover all of the items contained in the Operating and Maintenance Instructions.

13.2.4. Framed instructions, under glass or in laminated plastic, including wiring and control diagrams showing the complete layout of the entire system, shall be posted where directed. Condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system shall be prepared in typed form, framed as specified above for the wiring and control diagrams, and posted beside the diagrams. Proposed diagrams, instructions, and other sheets shall be submitted prior to posting. The framed instructions shall be posted before acceptance testing of the systems.

ZERO ACCIDENTS

SECTION 16643
CATHODIC PROTECTION (GALVANIC ANODE TYPE)

INDEX

Attachments: Anode Current Output Record
Std. Dwg. 40-06-15, Sheets 1, 2, 3, 4 and 5

1. **APPLICABLE PUBLICATIONS.** The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

1.1. FEDERAL SPECIFICATIONS (Fed. Spec.).

J-C-30A & Am-1 — Cable and Wire, Electrical (Power, Fixed Installation)

HH-I-595C — Insulation Tape, Electrical, Pressure-Sensitive Adhesive, Plastic

1.2. MILITARY SPECIFICATION (Mil. Spec.).

MIL-B-7883B — Brazing of Steels, Copper, Copper Alloys, Nickel Alloys, Aluminum and Aluminum Alloys

1.3. AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) PUBLICATION.

D 1248-84 — Polyethylene Plastics Molding and Extrusion Materials

1.4. NATIONAL ASSOCIATION OF CORROSION ENGINEERS (NACE) PUBLICATION.

RP-01-69 — Recommended Practice-Control of External Corrosion on Underground or Submerged Metallic Piping System (Rev. 1976)

1.5. NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA) STANDARD.

WC-5-1973 Incl Rev. 1 thru 11 — Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy

2. **GENERAL.** The contract drawings indicate the extent and general arrangement of the force main line. The cathodic protection system for the force main line shall be as specified herein. The electrical isolation and coatings of underground utilities, when not specified elsewhere, shall be included as a part of this section of these

specifications, and shall be in accordance with NACE RP-01-69. This specification applies to metal lines and structures that are coated. Please note that water lines may be either metal or non-metal, both cases are included as part of this specification. The metal lines shall require the number of anodes designated herein. Metal parts on non-metal lines shall require cathodic protection as described herein. Metal parts on non-metal lines include fire hydrants, couplings, 90 degree quarter turns, tee's, taps, fittings and valves plus any other metal parts used on the non-metal lines.

2.1. **STANDARD PRODUCTS.** Materials and equipment submitted for approval shall be a product of a manufacturer regularly engaged in the manufacture of the product, shall meet the requirements of the specifications, and essentially duplicate materials and equipment that have been in satisfactory use at least 2 years prior to bid opening.

2.2. **VERIFICATION OF SITE CONDITIONS.** The Contractor shall coordinate and properly relate his work to the site and to the work of all trades. The general locations of the lines and structures to receive protection are shown. The Contractor shall visit the premises and thoroughly familiarize himself with all details of the work and working conditions, shall verify existing conditions in the field, determine the exact locations of lines and structures to be protected, and advise the Contracting Officer of any discrepancy before performing any work.

2.3. **INSTALLATION METHODS.** The system installed shall comply with the applicable portions of NACE Standard RP-01-69.

3. **MATERIALS AND EQUIPMENT** shall conform to the respective specifications and other requirements specified herein.

3.1. **ANODES.**

3.1.1. Dimensions of magnesium anodes shall conform to the dimensions for standard sizes of anodes of the weights specified. The magnesium anode shall be of H-1, grade A alloy, conforming to the following:

Aluminum	5.3 - 6.7%
Manganese, min.	0.15
Zinc	2.5 - 3.5
Silicon, max.	0.10
Copper, max.	0.02
Nickel, max.	0.002
Iron, max.	0.003
Other impurities	0.3
Magnesium	Remainder

Contractor shall furnish spectrographic analyses or a letter of compliance on samples from each heat or batch of anodes used on this project.

3.1.2. Anodes shall be provided with specified backfill in a cloth sack. Anodes shall be centered in the backfill material. The total weight of the packaged anode shall be approximately as follows:

5 lb bare anode - 13 lb packaged anode

9 lb bare anode - 27 lb packaged anode

17 lb bare anode - 45 lb packaged anode

32 lb bare anode - 65 lb packaged anode

50 lb bare anode - 100 lb packaged anode

The backfill material shall consist of 75 percent gypsum, 20 percent bentonite, and 5 percent sodium sulfate, and shall be of the quick-wetting type.

3.1.3. Anode lead wires shall consist of insulated No. 12 solid copper wire. Lead wires shall be 10 feet in length.

3.2. **BRAZING** shall be in accordance with "Torch Brazing" requirements of Military Specification MIL-B-7883.

3.3. **CONDUCTORS** shall be copper except resistance wire and may have any of the following insulation types.

3.3.1. **Type TW and USE Insulation** shall comply with Fed. Spec. J-C-30.

3.3.2. **Polyethylene Insulation.** Cathodic protection cable specifically made for the purposes shall comply with ASTM D 1248 and shall be high molecular weight polyethylene, Type I, Class C, Grade E5, or NEMA WC-5, polyethylene insulation.

3.4. **TAPE.** Electrical tape pressure sensitive vinyl plastic shall comply with Fed. Spec. HH-I-595.

3.5. **BACKFILL SHIELD MATERIAL** shall be composed of approved pipeline wrapping or fiberglass reinforced coal-tar impregnated tape, or plastic weld caps specifically made for the purpose and installed in accordance with the manufacturer's directions.

3.6. **CURB BOX** shall be manufacturer's standard product of cast iron or plastic with a cast-iron top section and shall be complete with insulated four contact terminal strip and a tamper-proof cover with "C. P. Test" label on the cover. The plastic curb box with a cast-iron top section shall be a minimum of 4 inches I.D., 18-inch shaft length, flared end to prevent removal, cast-iron collar or top section and cast-iron cover.

3.7. **COATING COMPOUND** shall be cold applied coal-tar base mastic, hot- applied coal-tar enamel, or approved pipeline wrapping.

3.8. **RESISTANCE WIRE** shall be insulated type TW insulated nichrome wire, Agra #16 or #22 or 0.01 ohm shunt.

3.9. **WELDING** of electrical connections shall be as follows:

3.9.1. Exothermic type "Cadweld" or Burndy "Thermoweld," installed as directed by the manufacturer.

3.9.2. Other methods of welding specifically approved by the pipe manufacturer.

4. **SUBMITTALS.** In accordance with SECTION: SPECIAL CLAUSES, the Contractor shall submit for approval, data as specified herein on the following:

4.1. **CATEGORY I.**

Conductors (Para. 3.3)
Anodes (Para. 3.1)
Coating compound (Para. 3.7)
Backfill shield material (Para. 3.5)
Insulated resistance wire (Para. 3.8)
0.01 ohm shunt (Para. 3.8, 13.2)
Anode placement (Para. 6.2.1)
Layout of anodes around tanks (Para. 6.2.4)
Certified qualifications and experience data of installing firm and supervisor (Para. 5)
Exothermic weld equipment and material (Para. 3.9.1)
Curb box for test lead station (Para. 3.6)
Welding method for electrical connections (Para. 3.9)
Electrical isolation of structures and lines (Para. 10)

4.2. **CATEGORY II.**

Operation and Maintenance Manual (Para. 15)

5. **WORKMANSHIP.** The installation shall be supervised by a NACE Accredited Corrosion Specialist or Senior Corrosion Technologist. All materials and equipment shall be installed in accordance with the recommendations of the manufacturer as approved by the Contracting Officer to conform with the contract documents. The supervisor, as specified above, shall be on the site at least three times during construction and testing; once at the start of construction, once at approximately the mid-point of construction, and during the testing. The Specialist or Technologist shall do all testing. The Contractor shall submit certified qualifications and experience data of installing firm including: name of firm, number of years of experience, a list of not less than five of the firm's installations that are at least 3 years old which have been tested and found to be satisfactory, and the name and qualifications of the installing supervisor. Qualifications are when a person or firm is certified or accredited by the National Association of Corrosion Engineers (NACE) to perform such design or installation. In lieu of the NACE accreditation the person or firm must have at least 5 years of experience in the installation or design of Cathodic Protection Systems for buried metal structures and pipe lines. The person or firm shall also have a state license or certification to perform such installation or designs.

6. **ANODE PROTECTION AND INSTALLATION.**

6.1. **PROTECTION.** Storage area for magnesium anodes will be designated by the Contracting Officer. Anodes shall have approved waterproof protection at all times prior to installation. Damaged anodes shall be replaced. Remove waterproof protection before installing anode.

6.2. **INSTALLATION.** Unless otherwise authorized, installation shall not proceed without the presence of a representative of the Contracting Officer. Anodes of the size indicated herein shall be installed at the locations indicated herein. Locations may be changed to clear obstructions with the approval of the Contracting Officer.

6.2.1. **Anode Placement - General.** Packaged anodes shall be installed completely dry, and shall be lowered into holes by rope sling or by grasping the cloth gather. The anode lead wire shall not be used in lowering the anodes. The hole shall be backfilled with fine soil in

6-inch layers and each layer shall be hand tamped around the anode. Care must be exercised not to strike the anode or lead wire with the tamper. If immediate testing is to be performed, water shall be added only after backfilling and tamping has been completed to a point 6 inches above the anode. Approximately 5 gallons of water may be poured into the hole. After the water has been absorbed by the soil, backfilling and tamping may be completed to the top of the hole. Anodes shall be installed as shown on Std Dwg 40-06-15. In the event a rock strata is encountered prior to achieving specified augered-hole depth, anodes may be installed horizontally to a depth at least as deep as the bottom of the pipe, with the approval of the Contracting Officer.

6.2.2. **Underground Metal Fittings, Metal Couplings, and Valves When Used on Nonmetal Pipelines.** Each metal fitting, metal coupling, and valve shall have one 17-pound anode connected to it. Anodes shall be installed not less than 3 feet or more than 10 feet from the protected item. These anodes are required only when a nonmetallic pipe option is used.

6.2.3. **Underground Metal Pipeline.** The line shall have 5-17 lb. anodes spaced at equal intervals. Anodes shall be installed at a minimum of 3 feet and a maximum of 10 feet from the line to be protected.

6.2.4. **Plastic Warning Tape.** A 6-inch wide, 4-mil thick, yellow plastic warning tape with the words "CAUTION CATHODIC PROTECTION CABLE BURIED BELOW" permanently printed on the tape, shall be placed in the trench above the anode, anode lead wire, and wire-to-pipe connection. The tape shall be highly resistant to alkalies, acids, and other destructive agents found in the soil. The tape shall be buried above the anode, anode lead wire, and wire-to-pipe connection as close to the ground surface as possible to ensure maximum distance between the tape and the buried line and cable. The tape shall be installed in accordance with the manufacturer's recommendations.

7. **LEAD WIRE CONNECTIONS FOR ANODE AND TEST STATION.**

7.1. **UNDERGROUND PIPELINE.** Lead wire-to-structure connections shall be accomplished by exothermic welding process. A backfill shield shall be filled with mastic and placed over each connection and shall be of dimensions adequate to cover the exposed metals.

7.2. **LEAD AND RESISTANCE WIRE SPLICES.** All lead wire splicing, when necessary, shall be welded. The joint shall be epoxy insulated. Resistance wire connections shall be accomplished with silver solder and wrapped with a minimum of three layers of pressure sensitive tape.

8. **TEST STATIONS** shall be installed on the pipeline at the following locations.

8.1. At intervals not exceeding 500 feet, provide one test lead.

8.2. Where the pipe crosses within 6 inches of any other metal pipe, provide four test leads. Test leads will not be required within 300 feet of a riser pipe or any place where the pipe may be readily accessible.

8.3. Where a carrier pipe is used under roads or railroads, etc., or elsewhere, the second test lead shall be connected to the carrier pipe and the first test lead connected to the protected structure.

8.4. Provide a four wire test station at underground insulating joints. Connect a lead to each side of the joint.

8.5. Conductors shall be #12 AWG insulated, color coded as required. The upper end of the test station conductors shall be insulated with plastic tape or an insulated wire nut connector.

9. **UNDERGROUND PIPE JOINT BONDS.** All metal pipe joints except welded joints shall be electrically bonded. Bonding shall be made to the pipe on both sides of the joint and all component parts of the pipe joint except bolts. Joint bond conductor shall be #2 AWG copper with RHW-USE insulation conductors.

10. **TRENCHING AND BACKFILLING** shall be accomplished in accordance with SECTION: EXCAVATION, TRENCHING AND BACKFILLING FOR UTILITIES SYSTEMS and as shown on the drawings.

11. **TESTS AND MEASUREMENTS.** Unless otherwise authorized, tests shall not be made without the presence of a representative of the Contracting Officer. All test results and measurements shall be recorded and submitted as part of the O & M manual (see para. 15).

11.1. **ANODE TESTING - UNDERGROUND PIPELINE.** Prior to connection of the anode lead wire to the structure, and after backfilling around the anode and structure, a milliammeter will be inserted in the circuit and the current output of each anode measured and recorded (see attached "Anode Current Output Record"). In the event that maximum current outputs, as set forth below, for the different sizes of anodes should be exceeded, adequate resistance wire or shunt shall be inserted in the circuit to reduce the current output to the maximum allowable for a given size anode. Maximum allowable current outputs for the different size anodes to allow for design life shall be as shown in Table I below.

11.2. **MAXIMUM CURRENT TABLE.** Anodes of the various weights when tested shall not allow more than the following respective maximum current output.

TABLE I

Weight Bare Anode	Allowable Current Output
5# Anode	0.010 Amperes
9# Anode	0.020 Amperes
17# Anode	0.040 Amperes
32# Anode	0.080 Amperes
50# Anode	0.120 Amperes

11.3. **INSULATION TESTING.** At the time of anode installation, testing will be conducted at each insulating fitting to determine that no electrical contact or "short" exists between the two insulated structures. The Contractor shall be responsible for electrical isolation of all new structures. This phase of testing will be conducted utilizing a battery compass apparatus or other device specifically manufactured for this purpose. Insulated connections installed under this contract and found to be shorted shall be replaced by the Contractor.

11.4. **STRUCTURE-TO-SOIL POTENTIAL MEASUREMENTS.** Six weeks after completion of the cathodic protection installation, structure-to-soil potential measurements, with a copper/copper sulfate reference electrode, and using a potentiometer-voltmeter with a minimum internal resistance of 100,000 ohms, shall be made as follows:

11.4.1. Coated Piping.

11.4.1.1. With the test equipment properly connected and positioned, acquire potential readings at intervals not to exceed 500 feet. The reference electrode shall be positioned over the structure midway between anode locations.

11.4.2. Protective Criteria For Electrically Isolated Structures. Potential for protection of structures, pipe lines, and fittings shall be a minimum of negative 0.85 volt as measured between the structure and a saturated copper-copper sulphate reference cell contacting the earth directly over the structure.

11.4.3. Recording Measurements. All structure-to-soil potential measurements including native state potentials, and current measurements, shall be prepared in tabular form, and submitted in six copies, with each location identified on the as-built drawings. Contractor shall locate and correct and report to Contracting Officer any shorts to foreign structures encountered during check-out of the installed cathodic protection system. Structure-to-soil potential measurements are required on as many structures as necessary to determine the extent of protection or locate shorts.

11.5. **INSUFFICIENT PROTECTION.** In the event that the system, when installed in accordance with the plans and specifications, will not provide the required protection of negative 0.85 volt, the Contractor, together with the Contracting Officer, shall determine the cause and corrections needed. The Contractor shall be responsible for electrical isolation of all new piping, tanks, conduits, etc., in this contract. After the needed corrective actions have been so determined, the contract will be modified in accordance with clause entitled "Changes" of the contract clauses and the Contractor shall perform the additional work to provide at least a negative 0.85 volt protection for the system.

11.6. **INTERFERENCE TESTING** shall be made on all structures installed under this contract to locate damage being caused by existing impressed current cathodic protection systems or other sources of interference. It shall be the Contractor's responsibility to correct all interference using methods recommended by the Corrosion Technologist or Specialist. The methods used shall be shown on the as-built drawings and described in the test report.

12. **CLEANUP.** Contractor shall be responsible for cleanup at each anode installation site. All paper bags, wire clippings, etc., shall be disposed of as the Contracting Officer directs. Paper bags, wire clippings and other waste will not be put in bell hole or anode excavation.

13. **O & M MANUAL.** The Contractor shall prepare and furnish the Contracting Officer six copies of the operation and maintenance manual and as-built drawings of the cathodic protection system for guidance of Using Agency personnel.

13.1. **AS-BUILT DRAWINGS.** The Contractor shall maintain at the jobsite one set of full size contract drawings marked to show any deviations which have been made from the contract drawings. Upon completion of the work, the marked sets of prints shall be used to prepare as-built drawings. The drawings shall be prepared to a scale approved by the Contracting Officer and shall contain dimensioned locations of anodes, test stations, insulated flanges, dielectric unions, bonding connections and other underground structures.

ATTACHMENT 1 TO SECTION 16643

ANODE CURRENT OUTPUT RECORD

Location: _____ Sheet _____ of _____

Date: _____

	LOCATION		STRUCTURE	
Anode Size	(Refer to Bldg. Nos., Streets, Std. or Permanent Landmarks)	Gas	Tank	Current Output

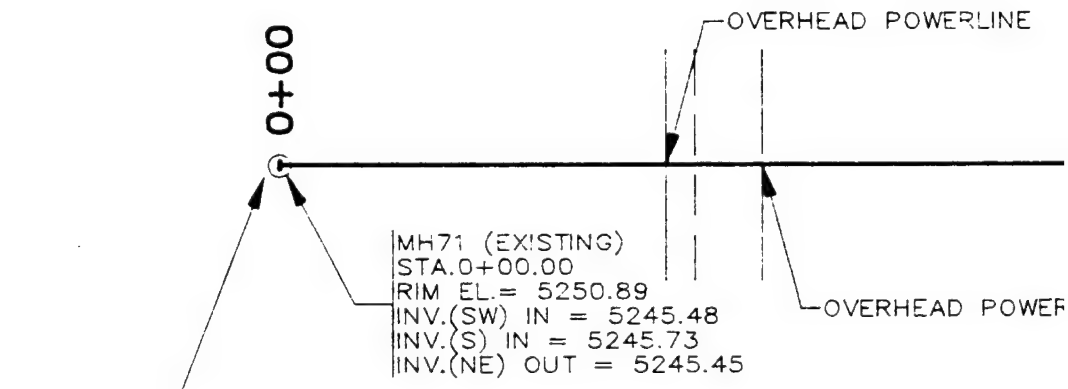
NOTE: Explanatory remarks, if required, can be entered on back of form.

APPENDIX C

D

LEGEND

℄ SEWER LINE	0+00	DIRT ROAD OR TRAIL	
EDGE OF PAVEMENT		RAILROAD	
FENCE	—X—X—	TREES	
PIPELINE	—I—I—	MANHOLE	
POWER/ UTILITY POLE	•	WELL	
2" PIPE	•MP		



NOTE:

CONTRACTOR SHALL CUT EXISTING M.H. NO. 71 AND INSTALL 3" D.I. FORCE MAIN AT THE INVERT EL. 5246.15. OPENING AROUND THE 3" FORCE MAIN AT THE MANHOLE SHALL BE COMPLETELY GROUT, INSIDE AND OUT.

4

IL

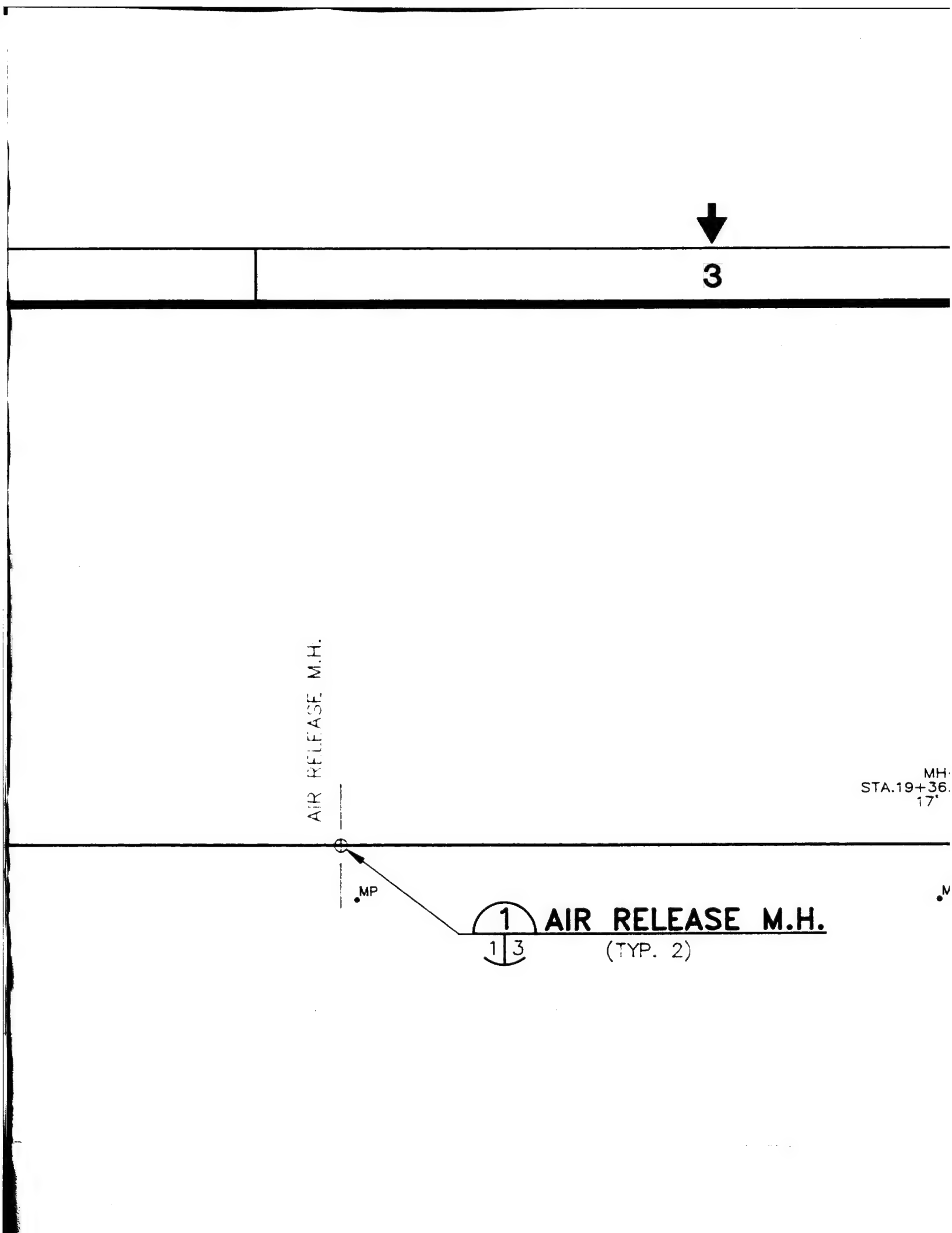
MH

W

LINE

10+00

POWERLINE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MP
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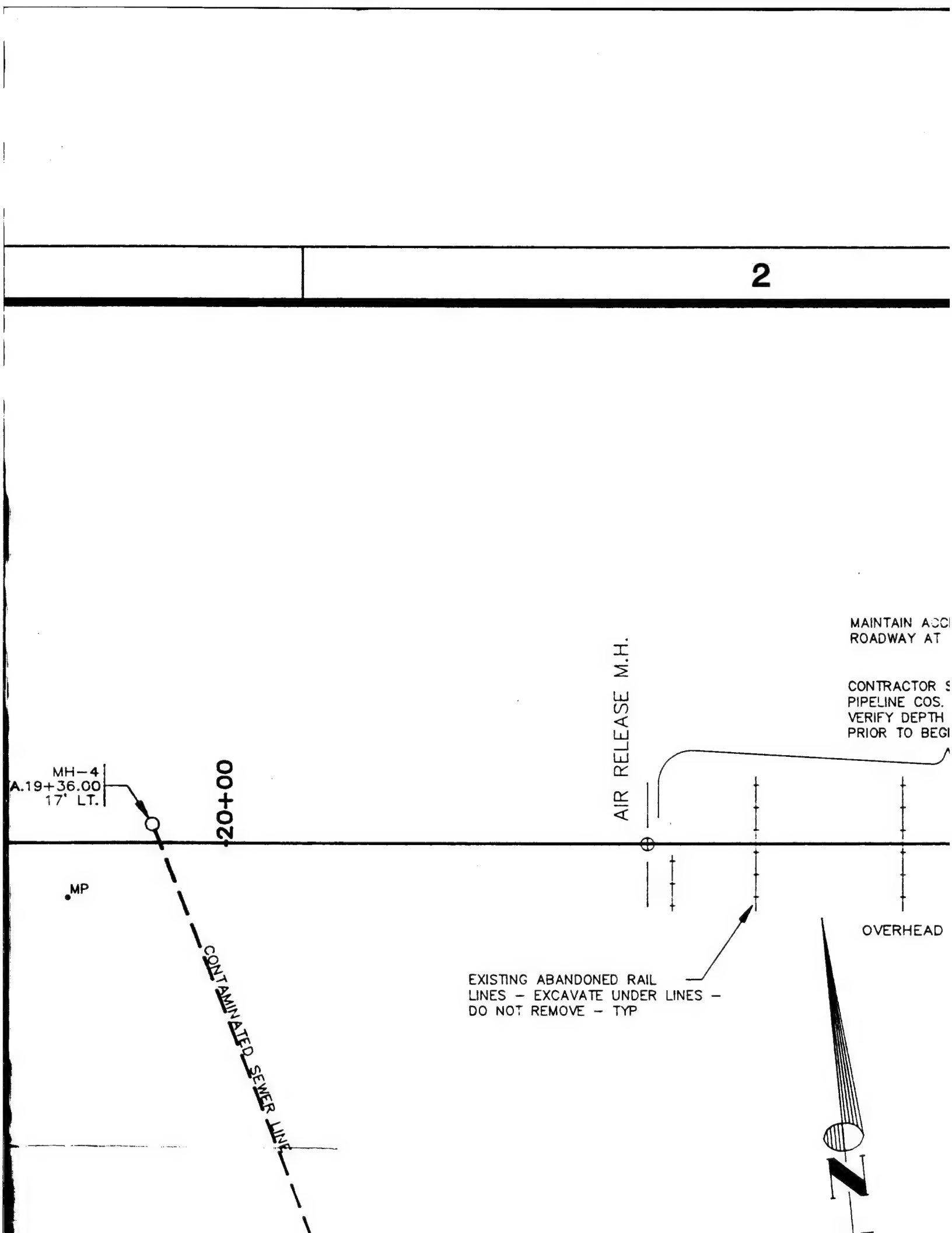
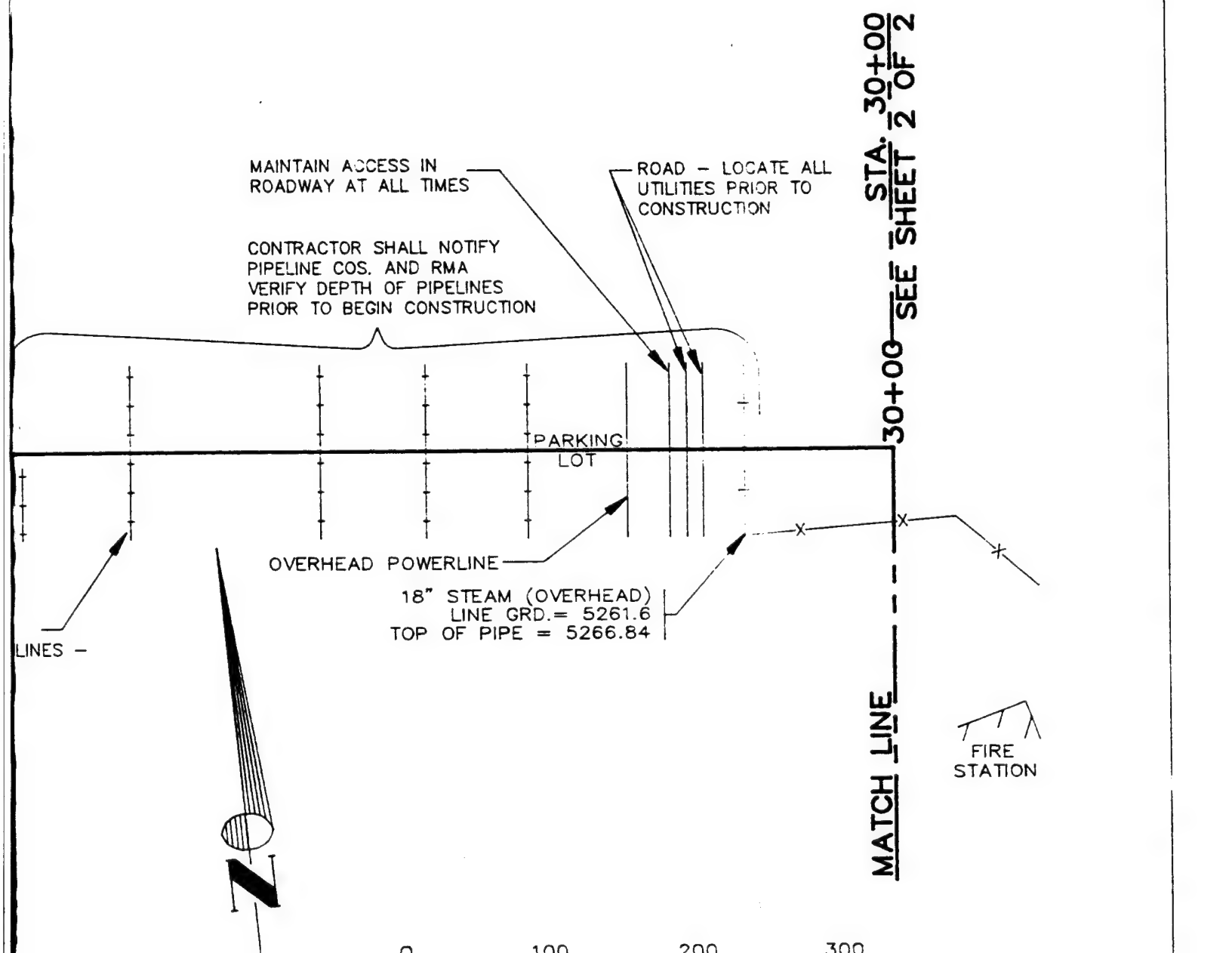
17'
1
1 3
AIR RELEASE M.H.
(TYP. 2)


MAINTAIN ACC
ROADWAY AT
CONTRACTOR S
PIPELINE COS.
VERIFY DEPTH
PRIOR TO BEGI
AIR RELEASE M.H.
MH-4
A.19+36.00
17' LT.
20+00
MP
OVERHEAD
EXISTING ABANDONED RAIL
LINES - EXCAVATE UNDER LINES -
DO NOT REMOVE - TYP
CONTAMINATED SEWER LINE
N


MAINTAIN ACCESS IN ROADWAY AT ALL TIMES
ROAD – LOCATE ALL UTILITIES PRIOR TO CONSTRUCTION
CONTRACTOR SHALL NOTIFY PIPELINE COS. AND RMA VERIFY DEPTH OF PIPELINES PRIOR TO BEGIN CONSTRUCTION
STA. 30+00 SEE SHEET 2 OF 2
30+00
PARKING LOT
OVERHEAD POWERLINE
18" STEAM (OVERHEAD) LINE GRD.= 5261.6 TOP OF PIPE = 5266.84
LINES –
MATCH LINE
FIRE STATION
N
0
100
200
300

CATE ALL
RIOR TO
TION

30+00 SEE SHEET 2 OF 2 STA. 30+00

MATCH LINE

FIRE
STATION

D

300

CONTRACTOR SHALL CUT EXISTING M.H. NO. 71 AND INSTALL 3" D.I. FORCE MAIN AT THE INVERT EL. 5246.15. OPENING AROUND THE 3" FORCE MAIN AT THE MANHOLE SHALL BE COMPLETELY GROUT, INSIDE AND OUT.

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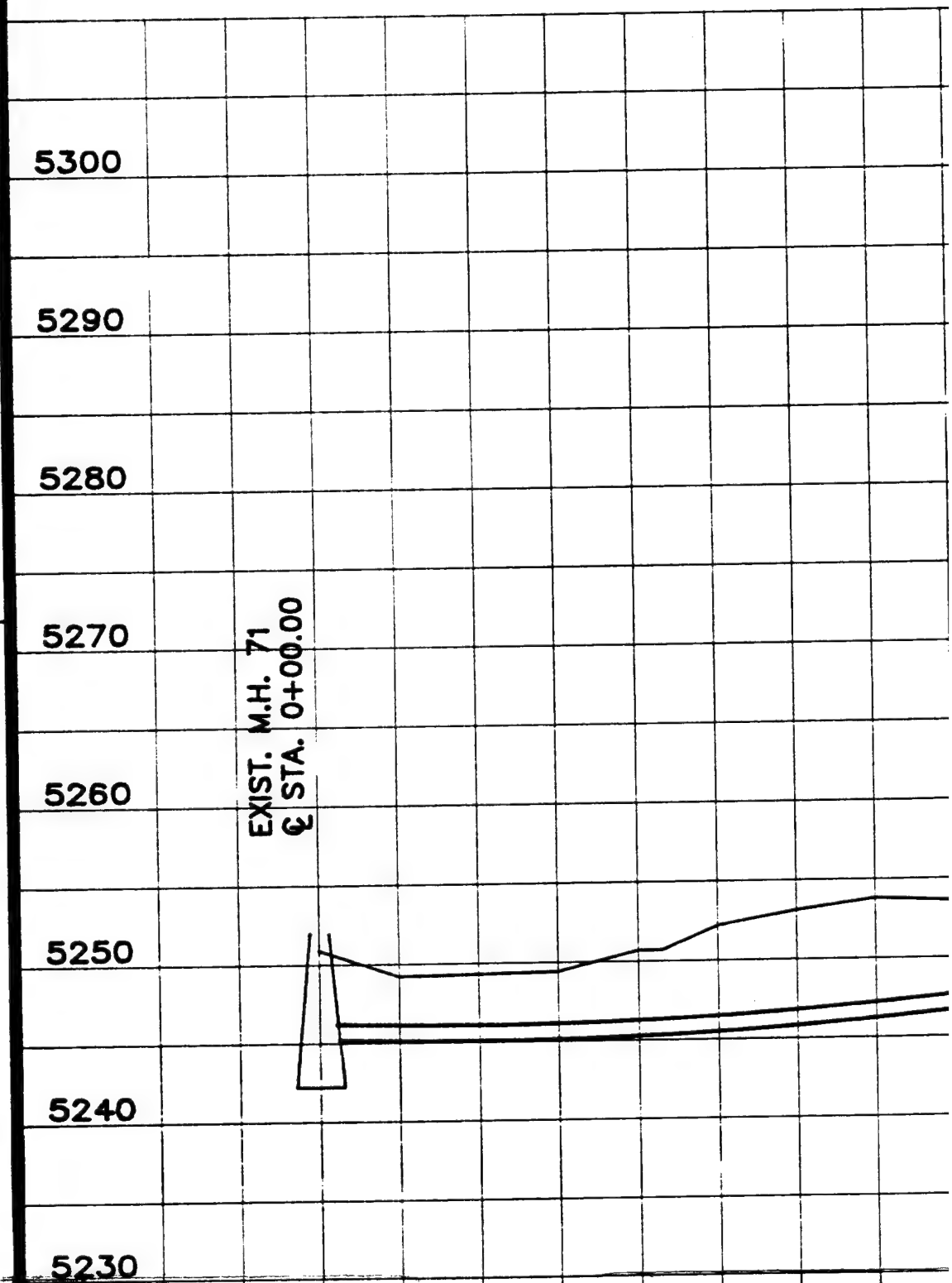
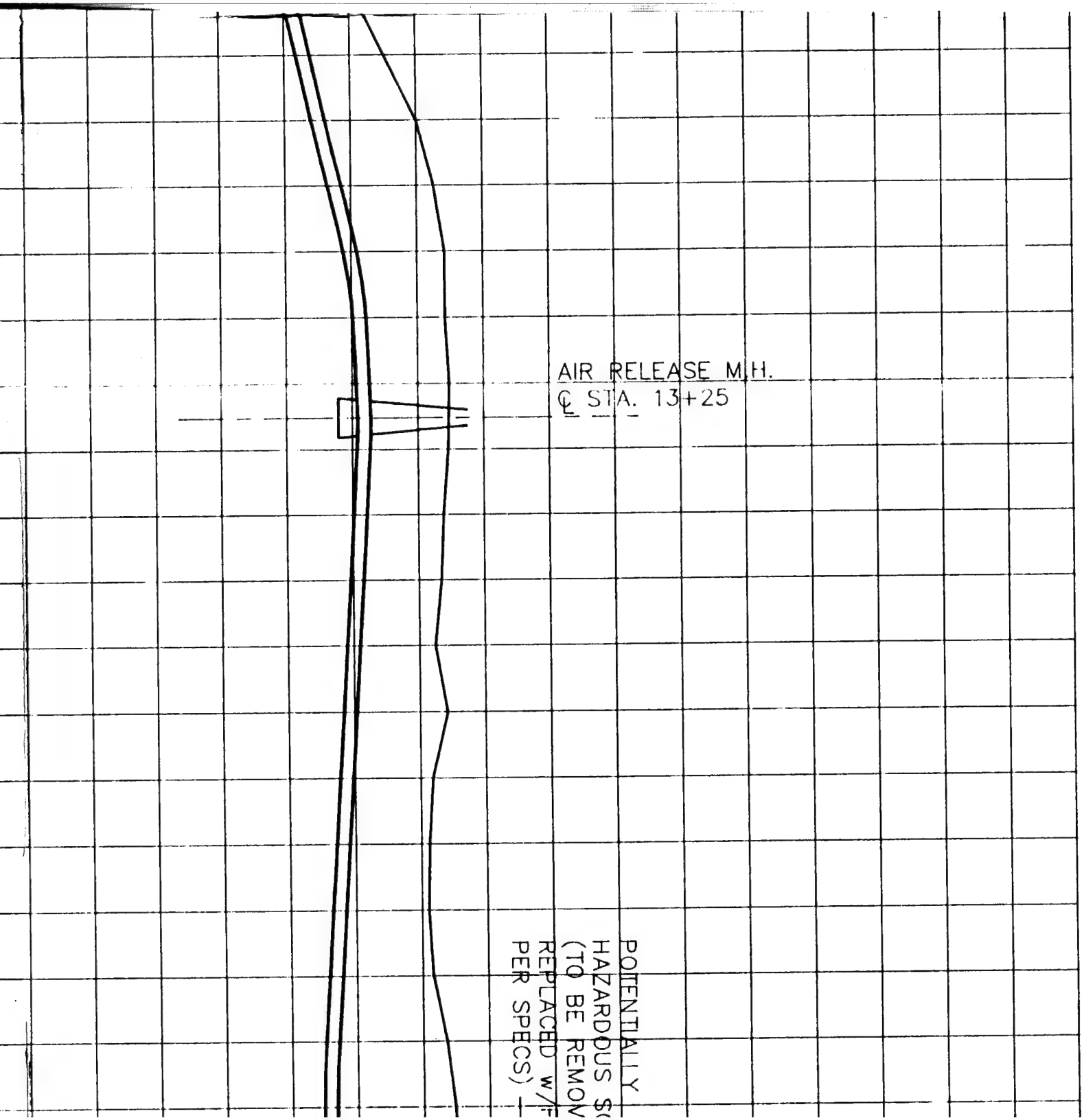


5' MIN. COVER (TYP.)
3" D.I.P. FORCE MAIN


AIR RELEASE M.H.
℄ STA. 13+25
POTENTIALLY
HAZARDOUS SC
(TO BE REMOV
REPLACED w/
PER SPECS)

EWER LINE

MH-5

N

ALLY
OUS SOIL
REMOVED &
D W/FILL
CS)

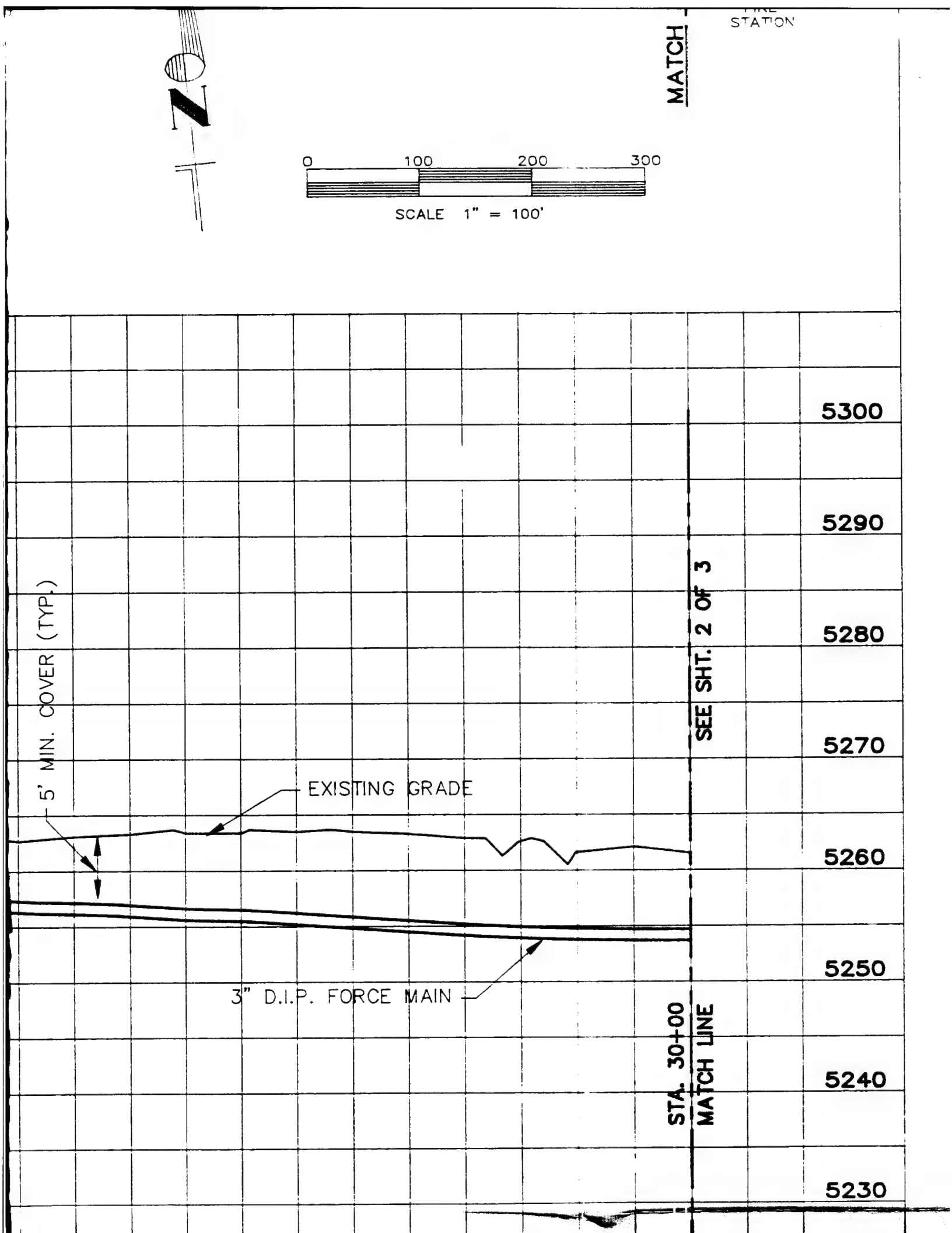
10' 10'

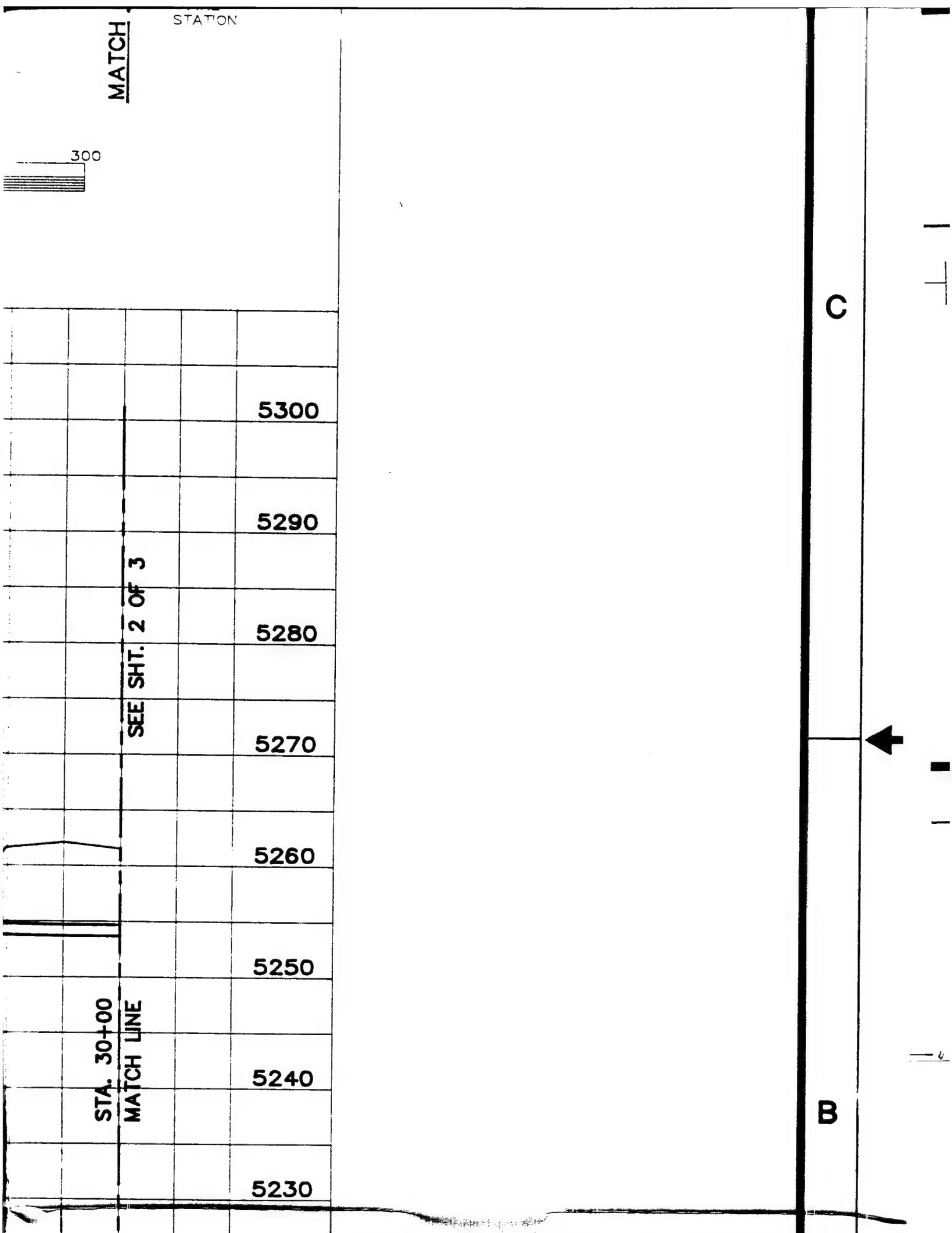
FIELD LOCATE
CONTAMINATED
SEWER

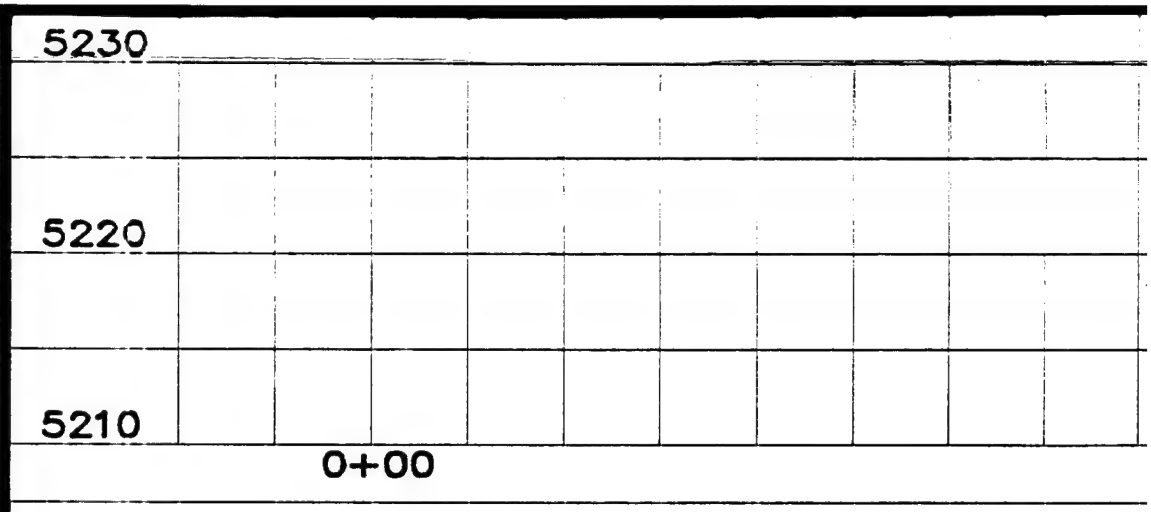
AIR RELEASE M.H.
℄ STA. 23+75

5' MIN. COVER (TYP.)

3" D.I


N
0
100
200
300
SCALE 1" = 100'
MATCH
FIRE STATION
5300
5290
5280
5270
5260
5250
5240
5230
SEE SHT. 2 OF 3
STA. 30+00
MATCH LINE
5' MIN. COVER (TYP.)
EXISTING GRADE
3" D.I.P. FORCE MAIN


STATION
MATCH
300
5300
5290
5280
5270
5260
5250
5240
5230
SEE SHT. 2 OF 3
STA. 30+00
MATCH LINE
C
B



SCALE

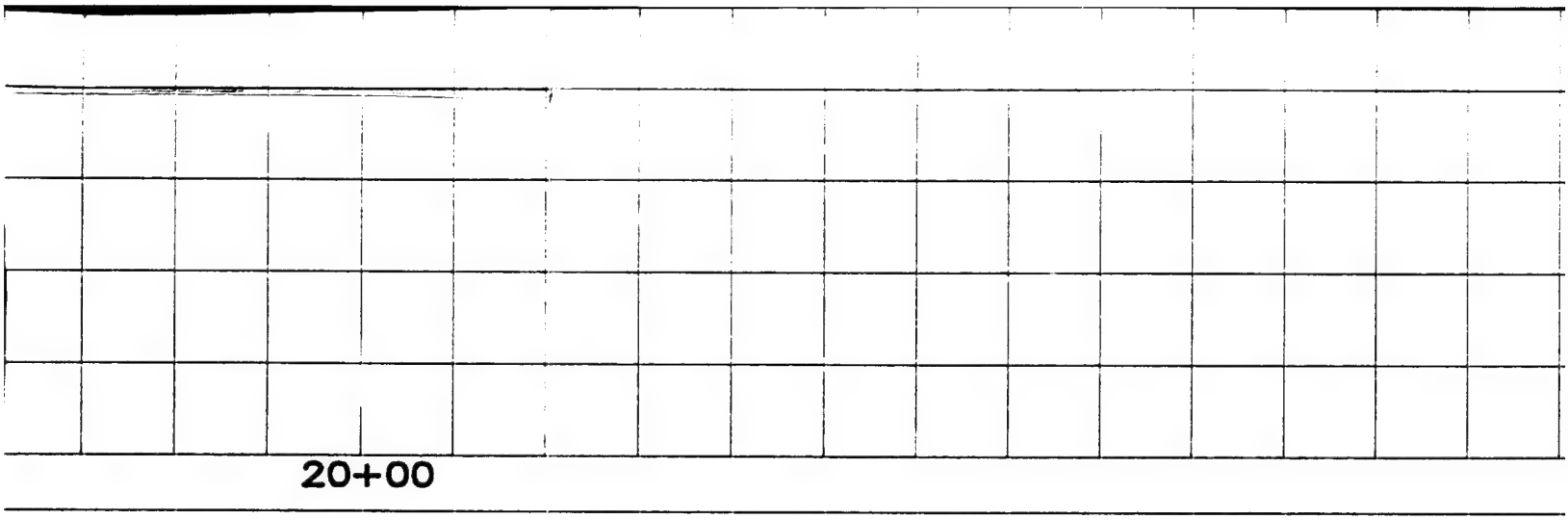
PLAN
1"= 100' Horiz.

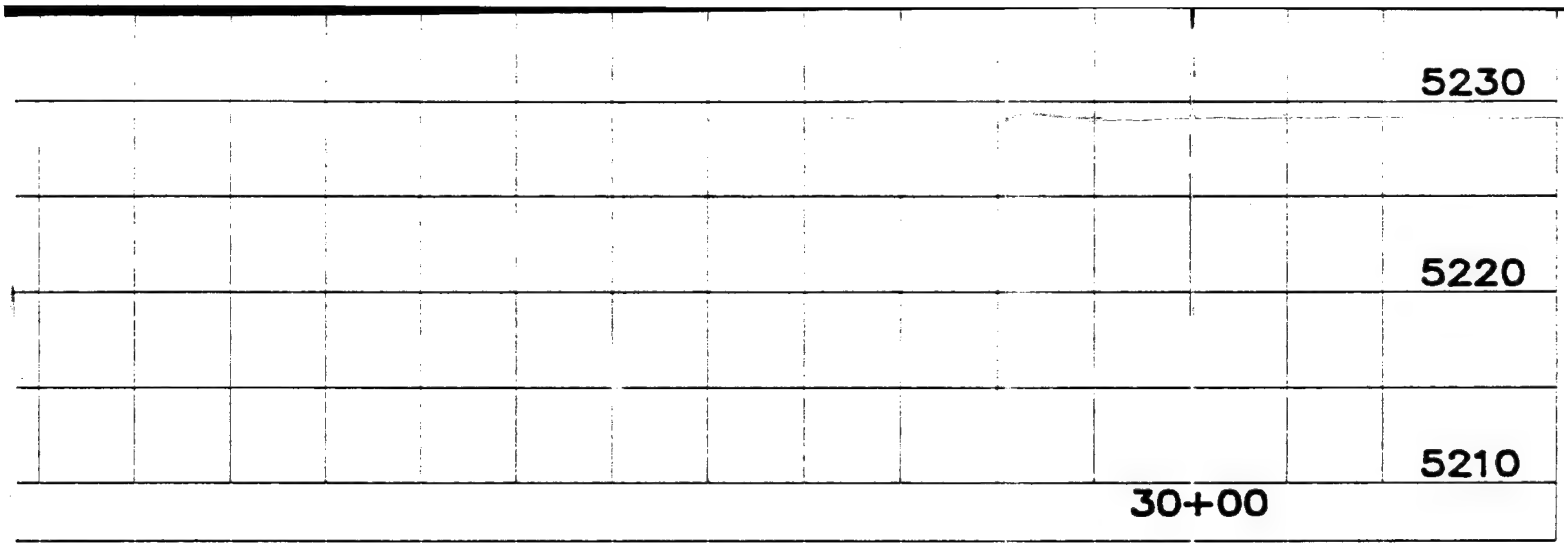
PROFILE
1"= 100' Horiz.
1'= 10' Vert.

A

RMA11111.1200MB011590

10+00


20+00



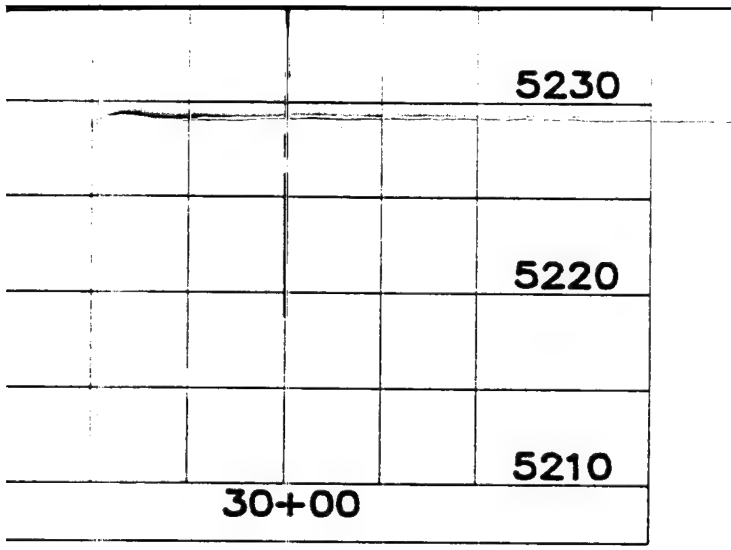
$$ THINK VALUE E

Symbol	Revisic Descriptions

ROY F. WESTON, INC.

DENVER, COLORADO

Designed by: MAA	ROCKY MOU PROPO
Drawn by: MMG	
Checked by: CPW	PLA
Reviewed by:	Scale: As Shown
	Spec. No.
Submitted by: Architect–Engineer	Contract No.



$$ THINK VALUE ENGINEERING $$

nbol	Revisions Descriptions	Date	Approved

ROY F. WESTON, INC.
DENVER, COLORADO

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
OMAHA, NEBRASKA

gned by: MAA
wn by: MMG
cked by: CPW
ewed by:
nitted by:
itect–Engineer

ROCKY MOUNTAIN ARSENAL, COLORADO
PROPOSED SANITARY SEWAGE
FORCE MAIN

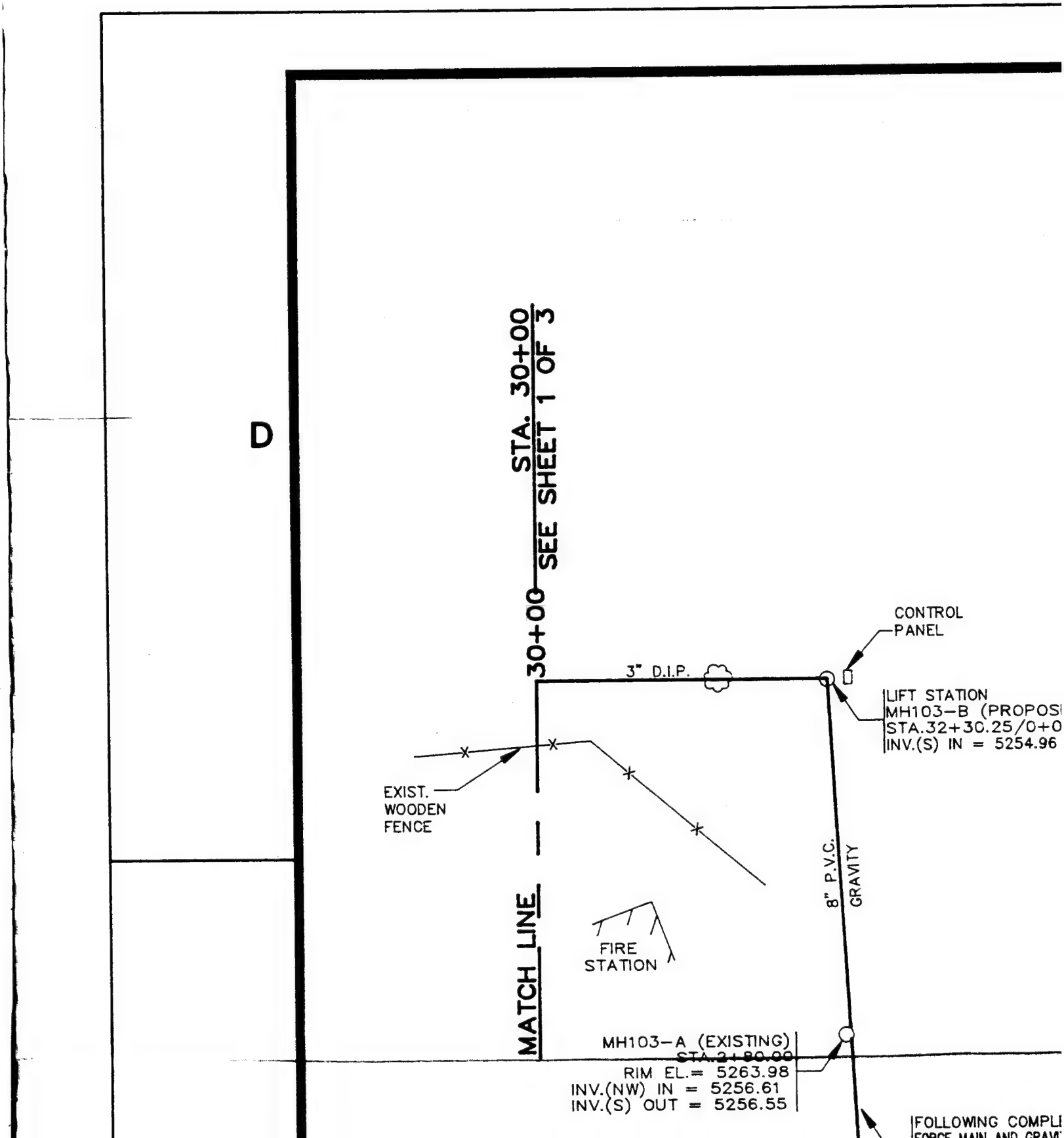
PLAN AND DETAILS

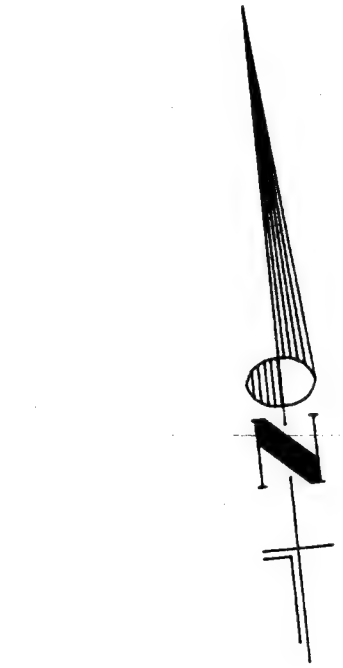
A

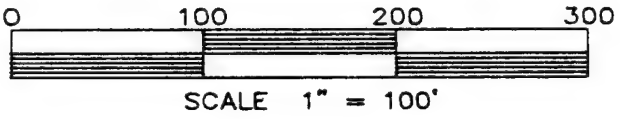
Scale: As Shown
Spec. No.
Contract No.

Sheet Reference Number. 1 OF 3

Date: JANUARY 1990
Drawing Code:


D
STA. 30+00
SEE SHEET 1 OF 3
30+00
CONTROL PANEL
3" D.I.P.
LIFT STATION
MH103-B (PROPOSE
STA.32+30.25/0+0
INV.(S) IN = 5254.96
EXIST. WOODEN FENCE
8" P.V.C. GRAVITY
MATCH LINE
FIRE STATION
MH103-A (EXISTING)
STA.2+80.00
RIM EL.= 5263.98
INV.(NW) IN = 5256.61
INV.(S) OUT = 5256.55
FOLLOWING COMPLE
FORCE MAIN AND GRAVI

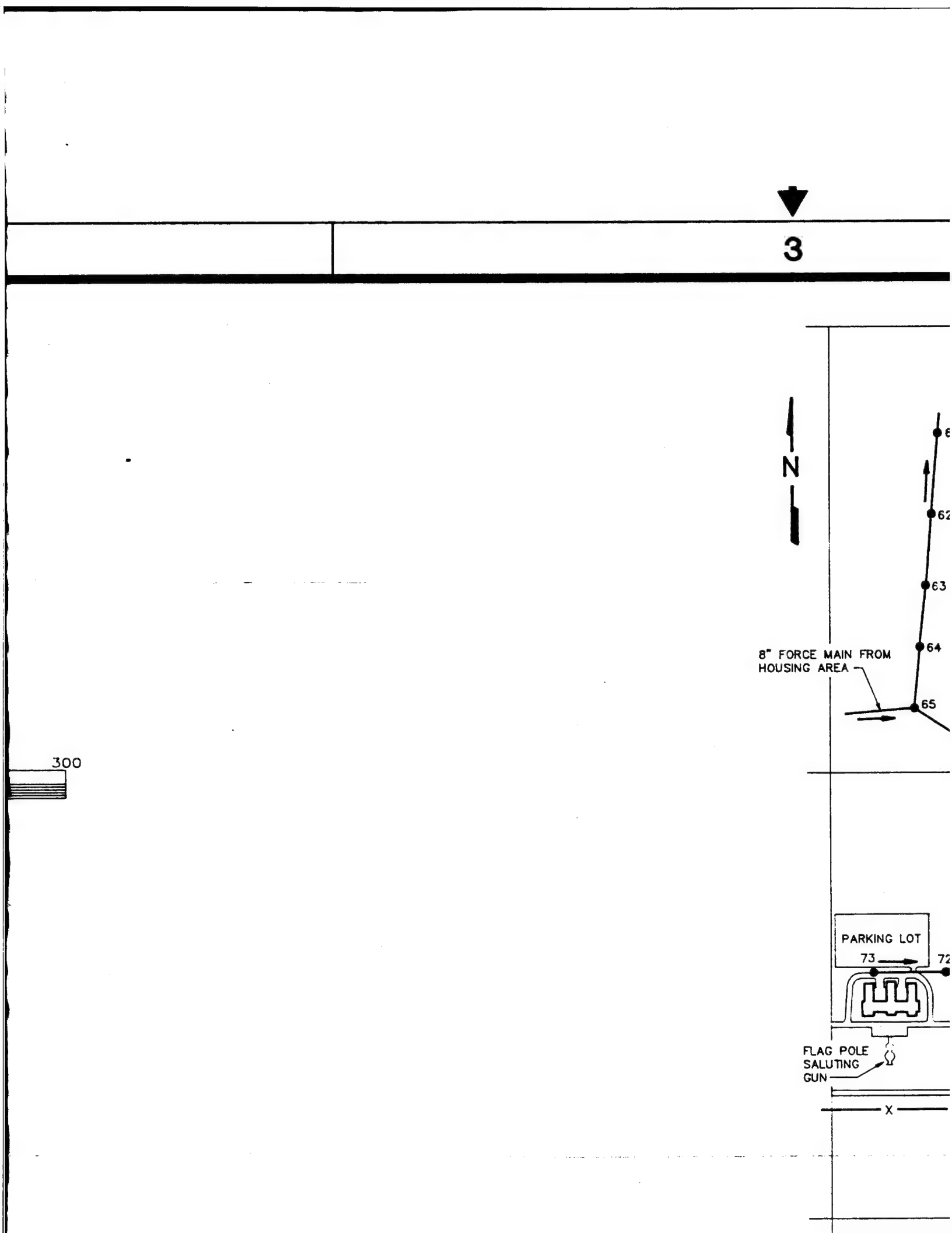


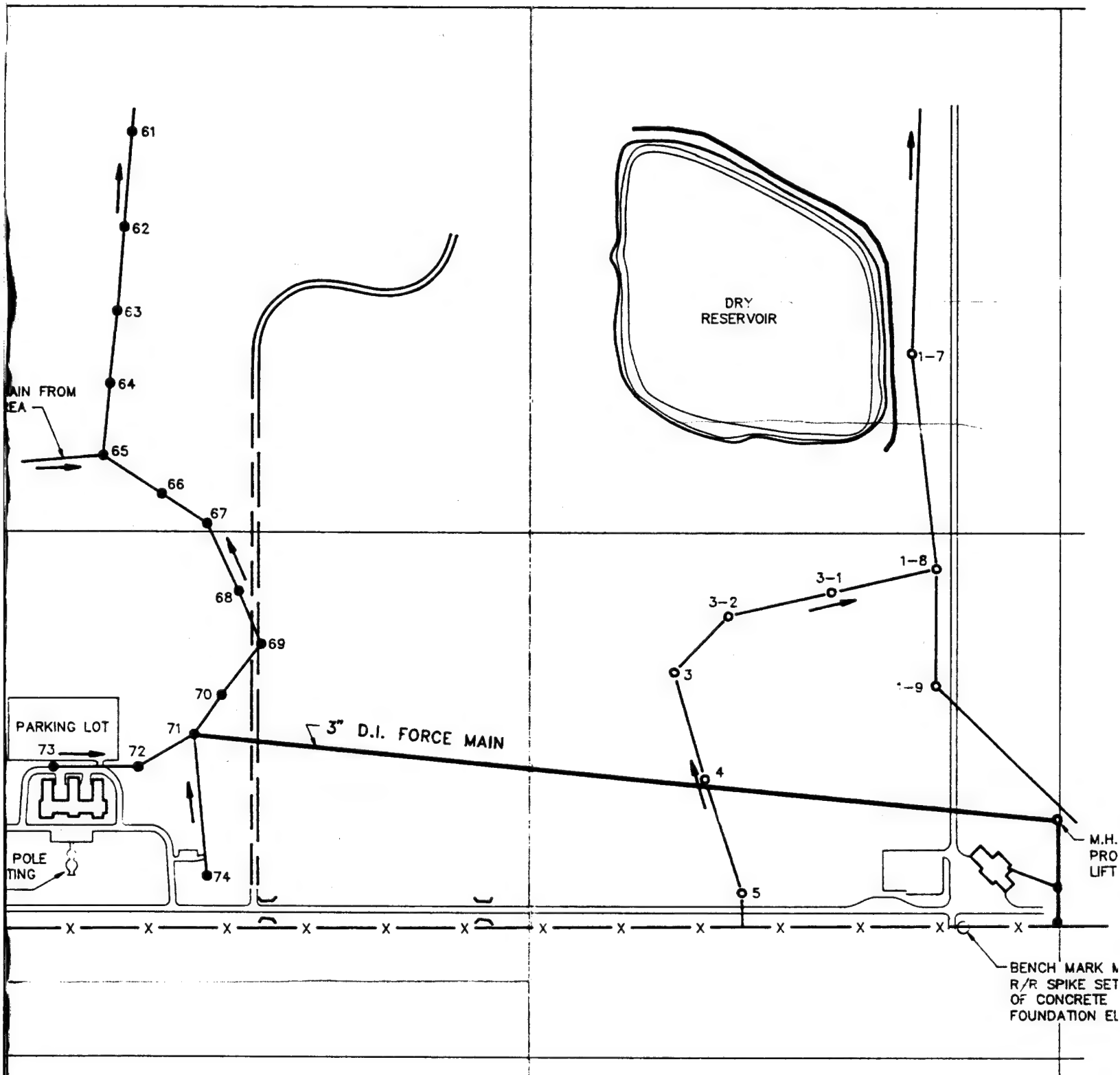


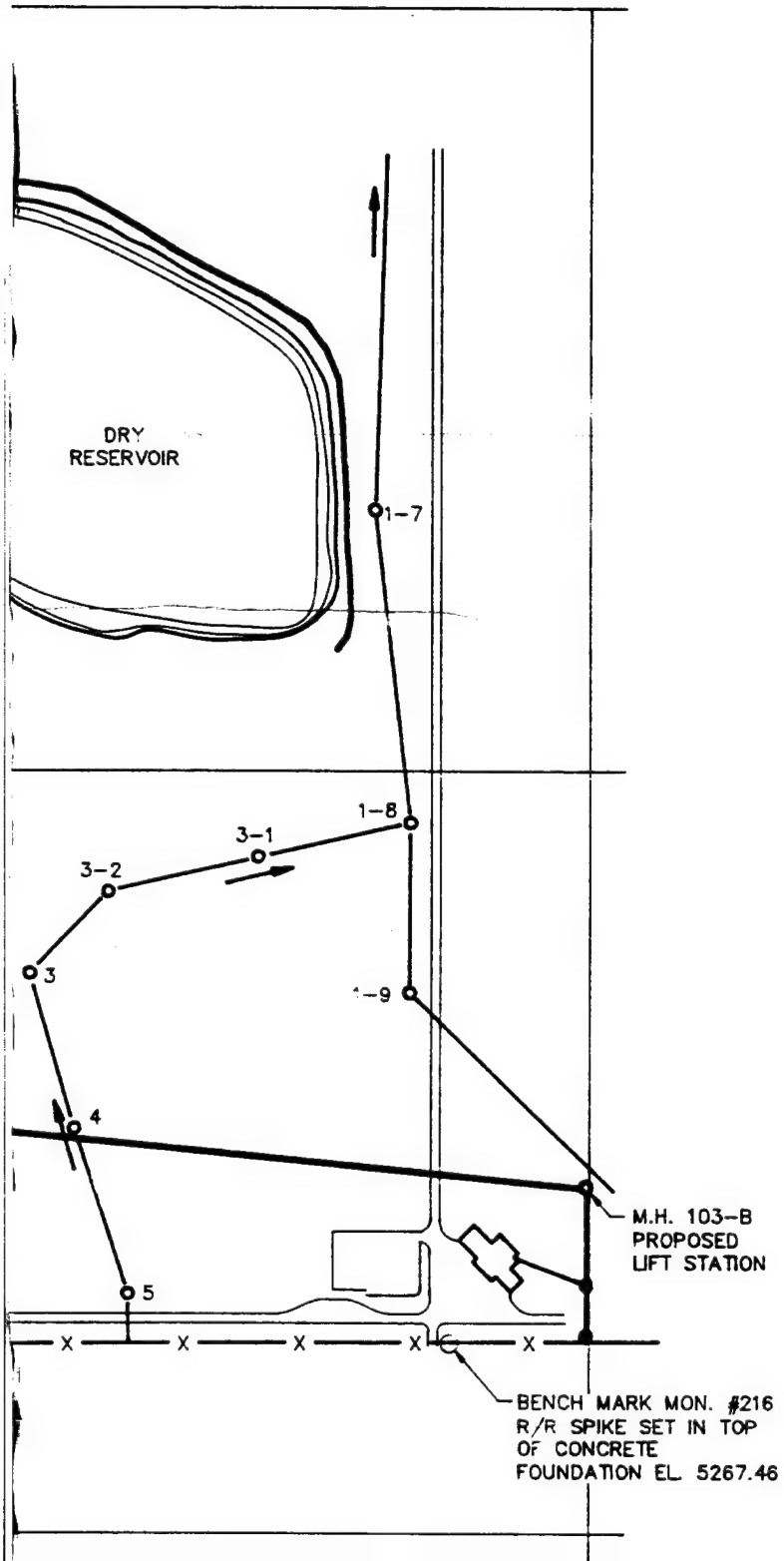
SCALE 1" = 100'

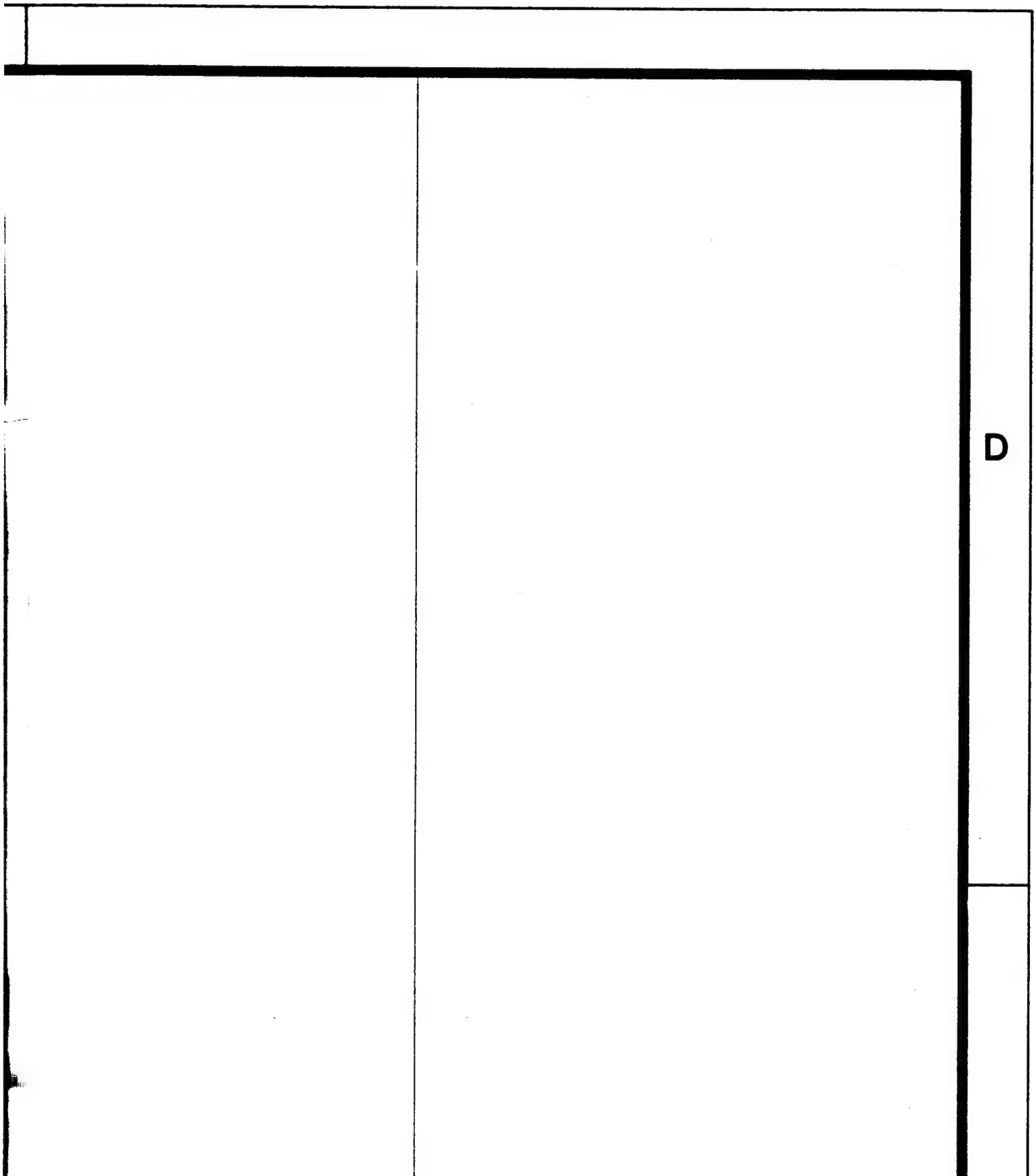
(PROPOSED)
125/0+00.00
= 5254.96

NG COMPLETION OF
N AND GRAVITY LINE


3
N
8" FORCE MAIN FROM HOUSING AREA
62
63
64
65
300
PARKING LOT
73
FLAG POLE
SALUTING
GUN
X


61
62
63
64
65
66
67
68
69
70
71
72
73
74
AIN FROM
EA
DRY
RESERVOIR
1-7
1-8
3-1
3-2
3
1-9
4
5
PARKING LOT
3" D.I. FORCE MAIN
POLE
TING
M.H.
PRO
LIFT
BENCH MARK
R/R SPIKE SET
OF CONCRETE
FOUNDATION EL


DRY
RESERVOIR
1-7
1-8
3-1
3-2
3
1-9
4
5
M.H. 103-B
PROPOSED
LIFT STATION
X
X
X
X
X
BENCH MARK MON. #216
R/R SPIKE SET IN TOP
OF CONCRETE
FOUNDATION EL. 5267.46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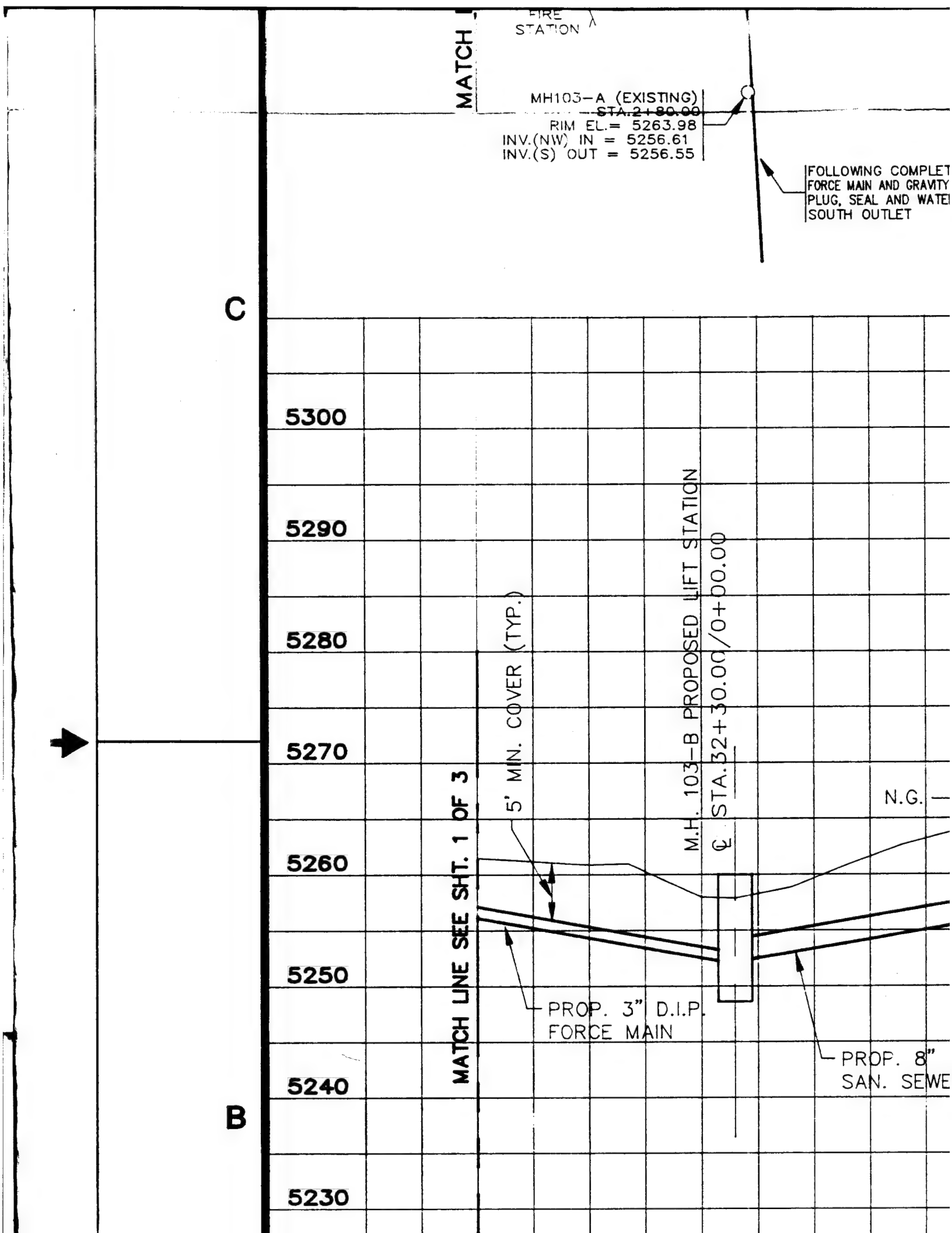
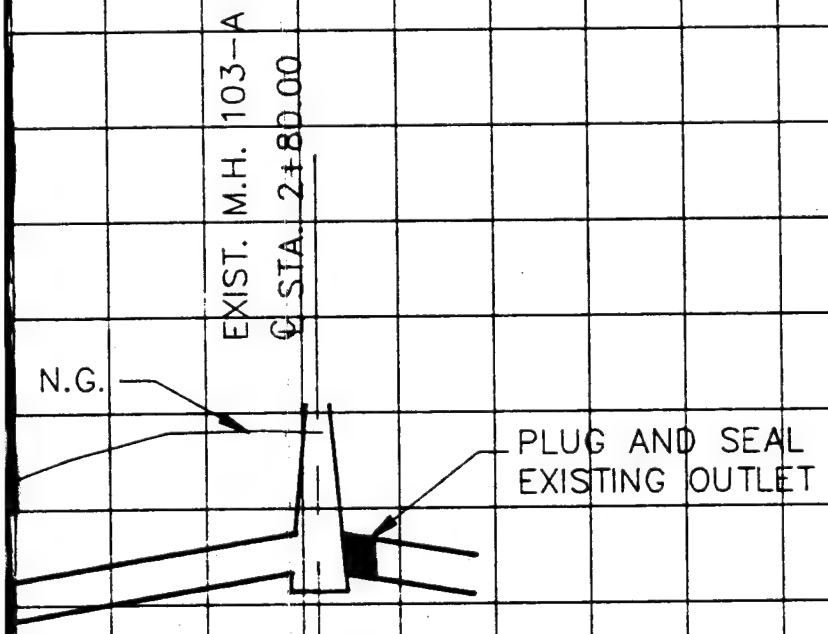
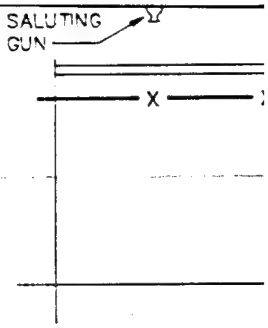
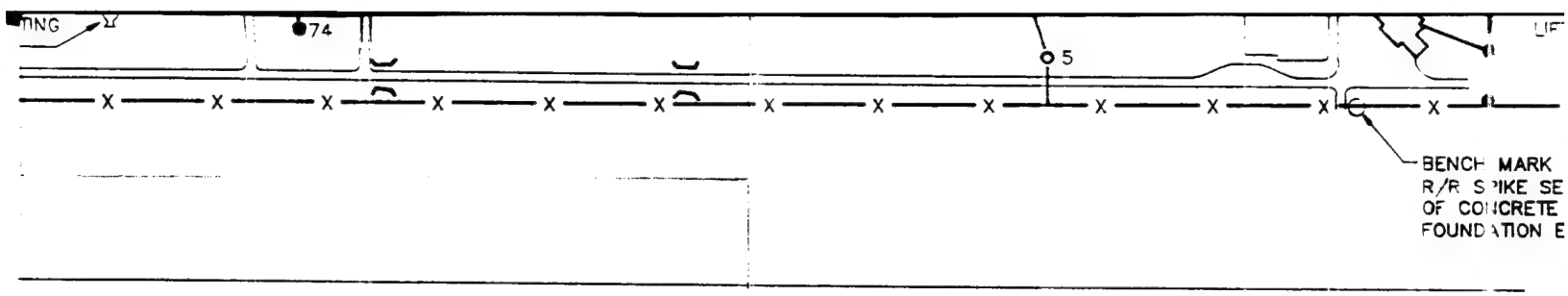

MATCH
FIRE STATION
MH103-A (EXISTING)
STA.2+80.00
RIM EL.= 5263.98
INV.(NW) IN = 5256.61
INV.(S) OUT = 5256.55
FOLLOWING COMPLET
FORCE MAIN AND GRAVITY
PLUG, SEAL AND WATE
SOUTH OUTLET
C
B
5300
5290
5280
5270
5260
5250
5240
5230
MATCH LINE SEE SHT. 1 OF 3
5' MIN. COVER (TYP.)
M.H. 103-B PROPOSED LIFT STATION
℄ STA.32+30.00/0+00.00
N.G.
PROP. 3" D.I.P.
FORCE MAIN
PROP. 8"
SAN. SEWE

G COMPLETION OF
AND GRAVITY LINE
L AND WATERPROOF
UTLET



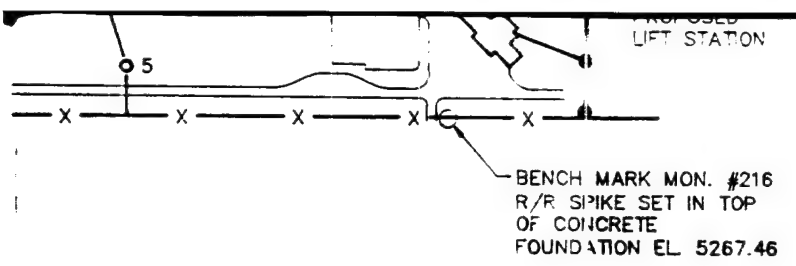
OP. 8" P.V.C.
N. SEWER @ 0.58%

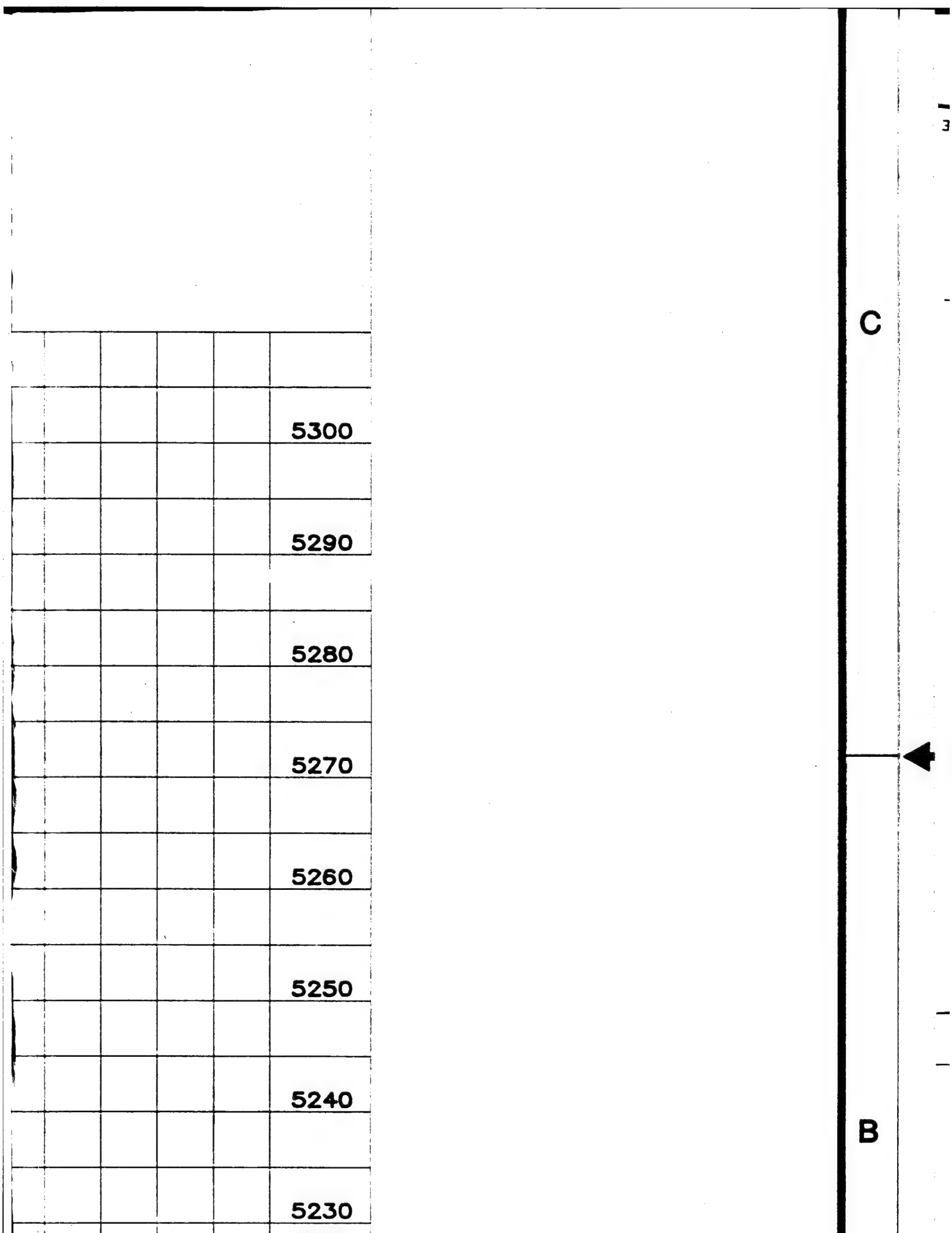

SALUTING
GUN
X

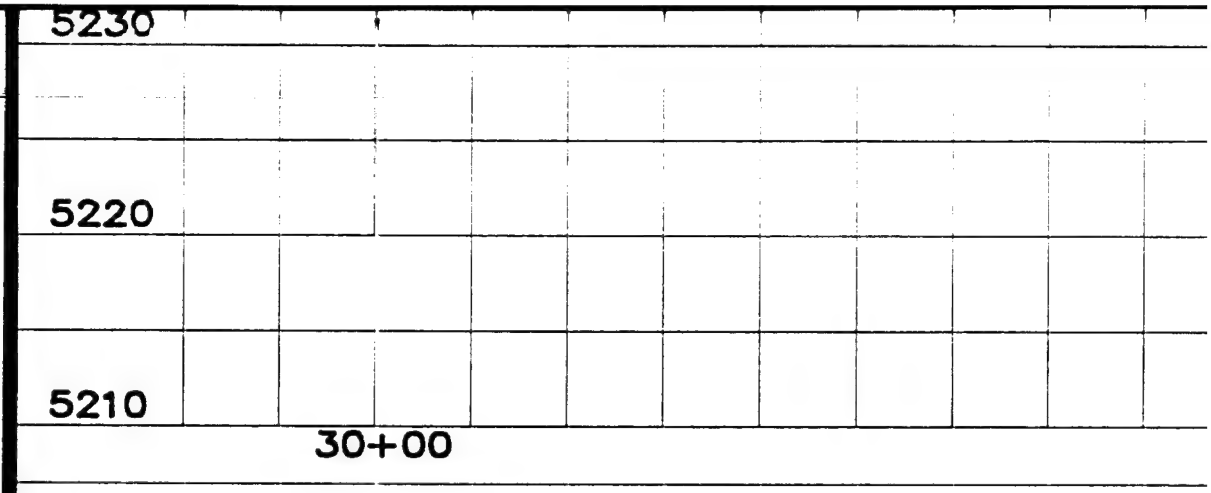


LOCATION PLAN

SCALE 1"=500'


LIFT STATION
5
X
X
X
X
X
BENCH MARK MON. #216
R/R SPIKE SET IN TOP
OF CONCRETE
FOUNDATION EL. 5267.46


5300
5290
5280
5270
5260
5250
5240
5230
C
B



SCALE

PLAN
1"= 100' Horiz.

PROFILE
1"= 100' Horiz.
1'= 10' Vert.

A

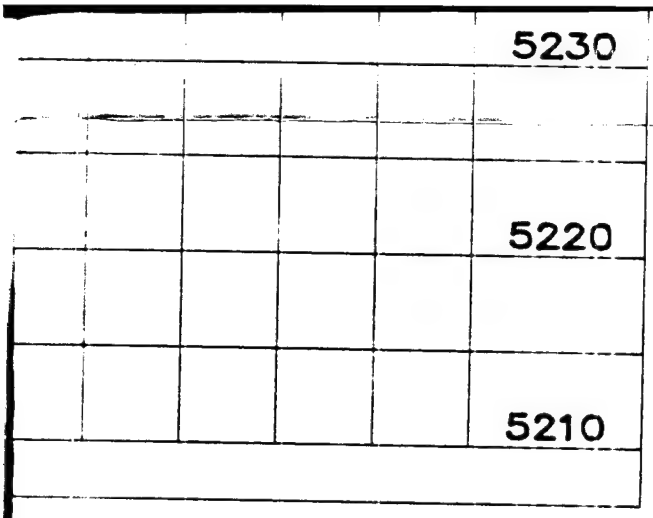
RMA1112.1200MB011590

$$	
Symbol	Desc

ROY F. WEST

DENVER, COL

Designed by: MAA	
Drawn by: MMG	
Checked by: CPW	
Reviewed by:	S
	S
Submitted by: Architect–Engineer	C

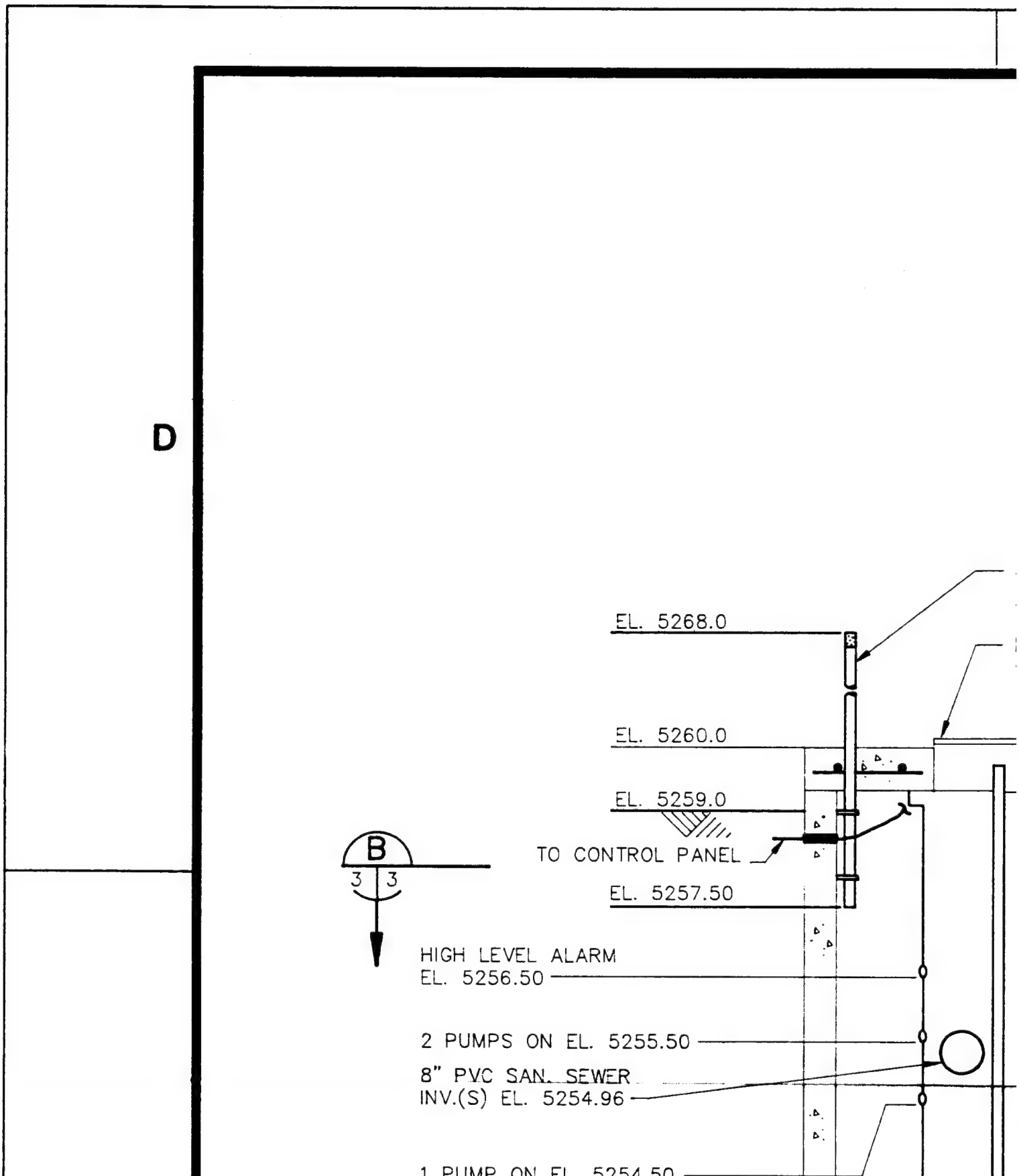


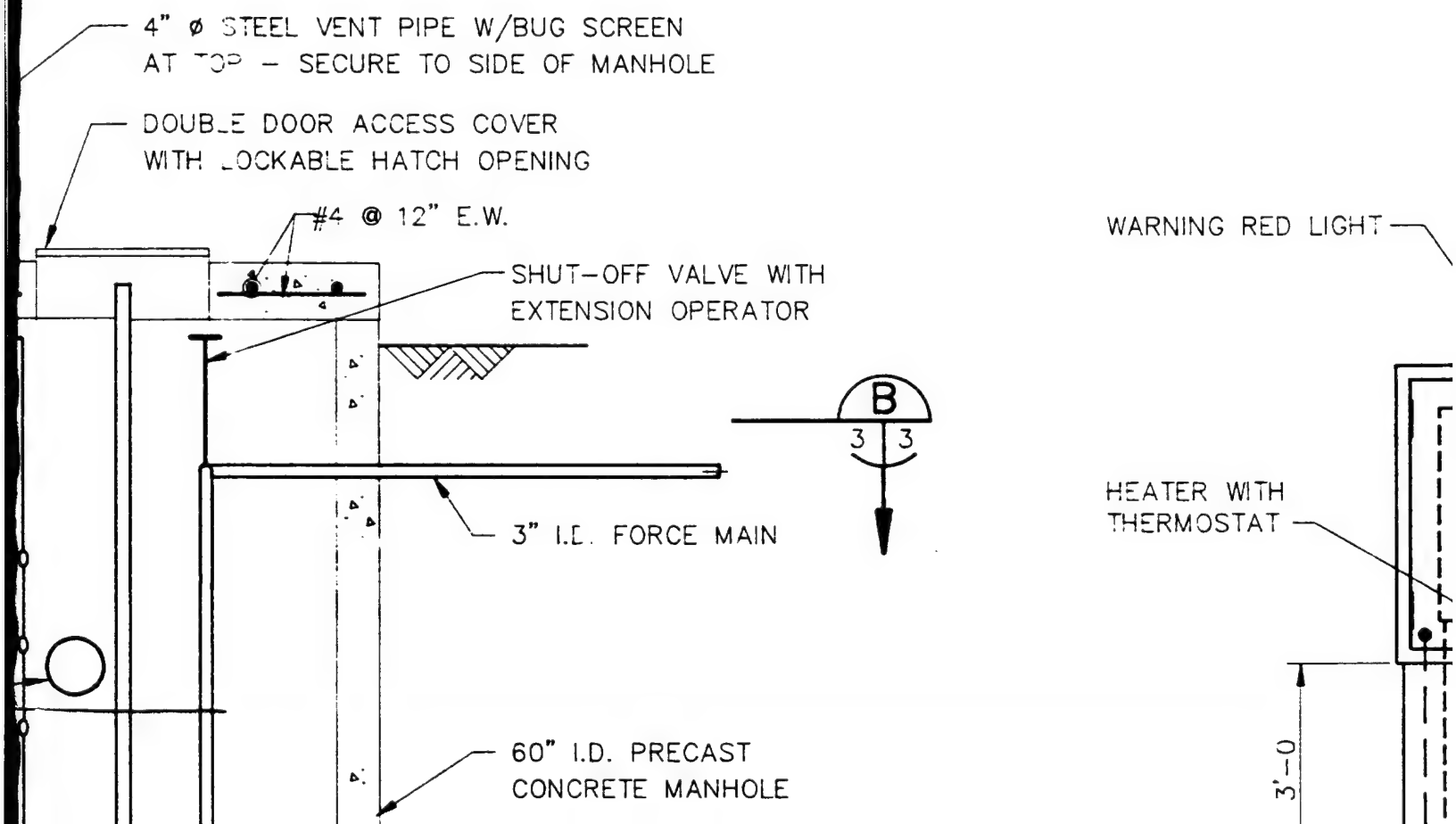
$$ THINK VALUE ENGINEERING $$

bol	Revisions Descriptions	Date	Approved

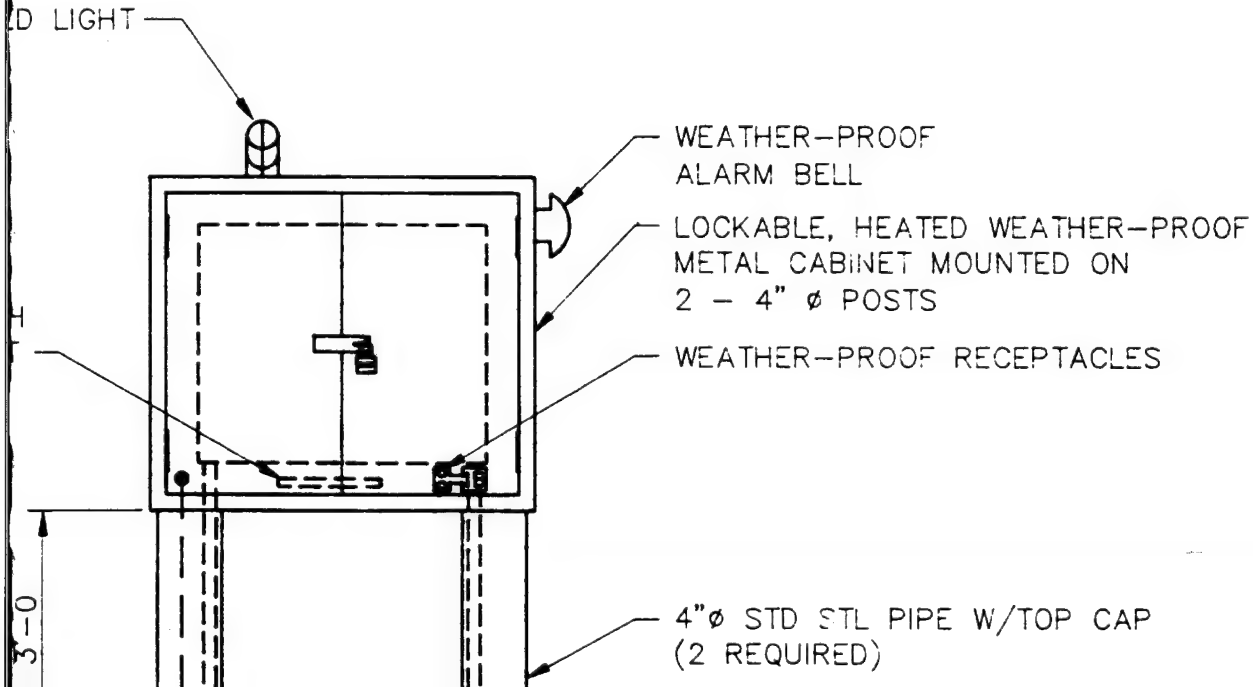
OY F. WESTON, INC. DENVER, COLORADO	U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS OMAHA, NEBRASKA

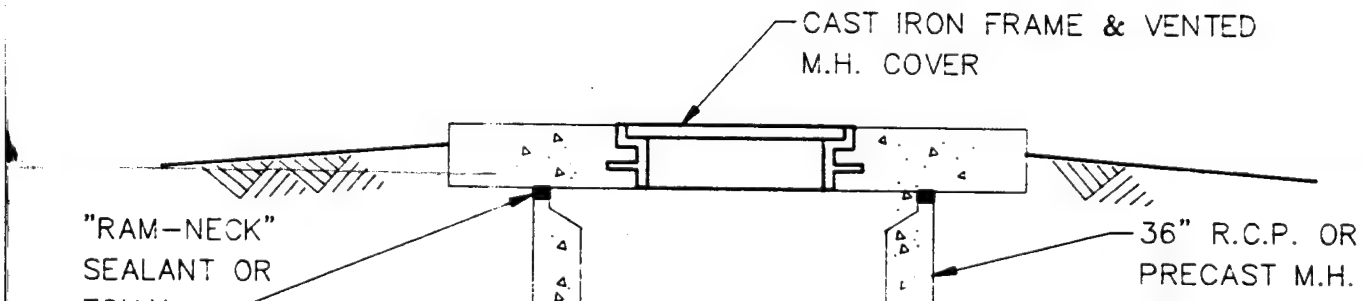
ned by: MAA n by: MMG ked by: CPW	ROCKY MOUNTAIN ARSENAL, COLORADO PROPOSED SANITARY SEWAGE FORCE MAIN **PLAN AND DETAILS**		A
wed by: itted by: ect–Engineer	Scale: As Shown Spec. No. Contract No.	Sheet Reference Number. 2 OF 3	Date: JANUARY 1990 Drawing Code:


D
EL. 5268.0
EL. 5260.0
EL. 5259.0
TO CONTROL PANEL
EL. 5257.50
B
3
3
HIGH LEVEL ALARM
EL. 5256.50
2 PUMPS ON EL. 5255.50
8" PVC SAN. SEWER
INV.(S) EL. 5254.96
1 PUMP ON EL. 5254.50

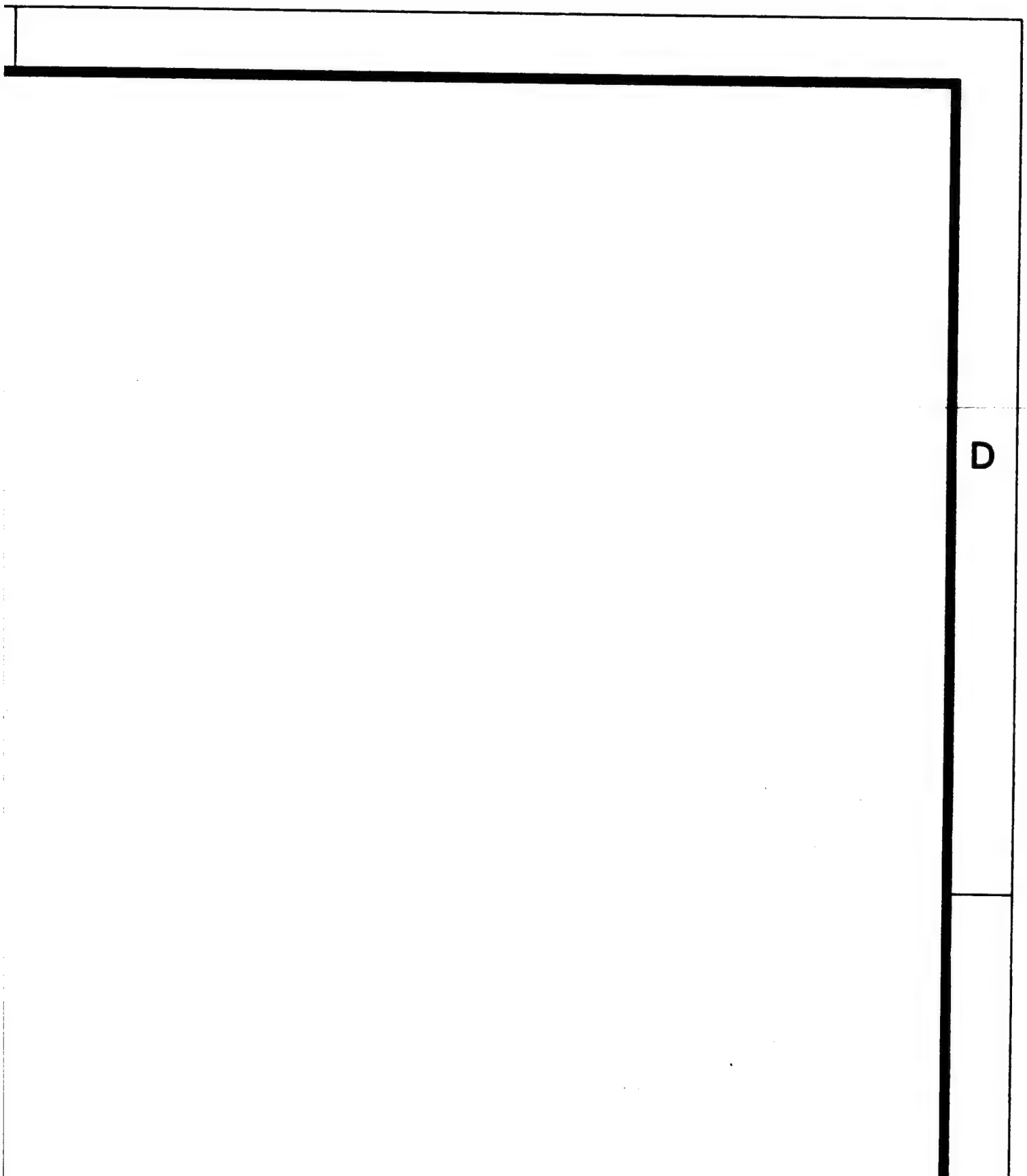

4" ø STEEL VENT PIPE W/BUG SCREEN
AT TOP – SECURE TO SIDE OF MANHOLE
DOUBLE DOOR ACCESS COVER
WITH LOCKABLE HATCH OPENING
#4 @ 12" E.W.
SHUT–OFF VALVE WITH
EXTENSION OPERATOR
B
3 3
3" I.D. FORCE MAIN
60" I.D. PRECAST
CONCRETE MANHOLE
WARNING RED LIGHT
HEATER WITH
THERMOSTAT
3'-0

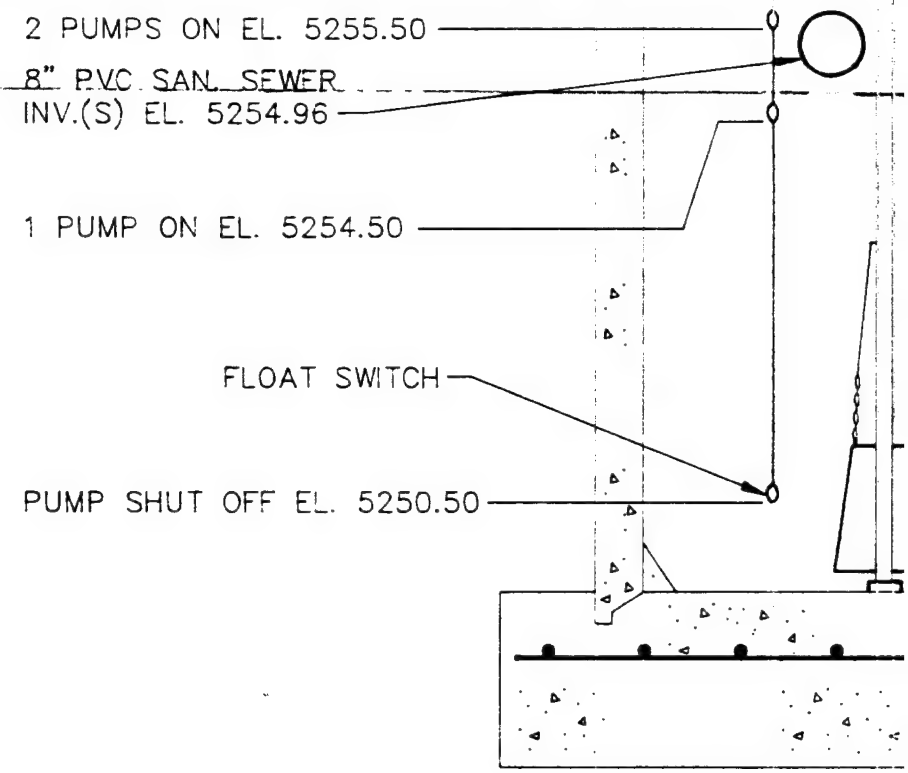
3


D LIGHT
WEATHER–PROOF
ALARM BELL
LOCKABLE, HEATED WEATHER–PROOF
METAL CABINET MOUNTED ON
2 – 4" ø POSTS
WEATHER–PROOF RECEPTACLES
4"ø STD STL PIPE W/TOP CAP
(2 REQUIRED)
"RAM–N
SEALAN


CAST IRON FRAME & VENTED
M.H. COVER
"RAM-NECK"
SEALANT OR
36" R.C.P. OR
PRECAST M.H.

C.P. OR
ST M.H.


D



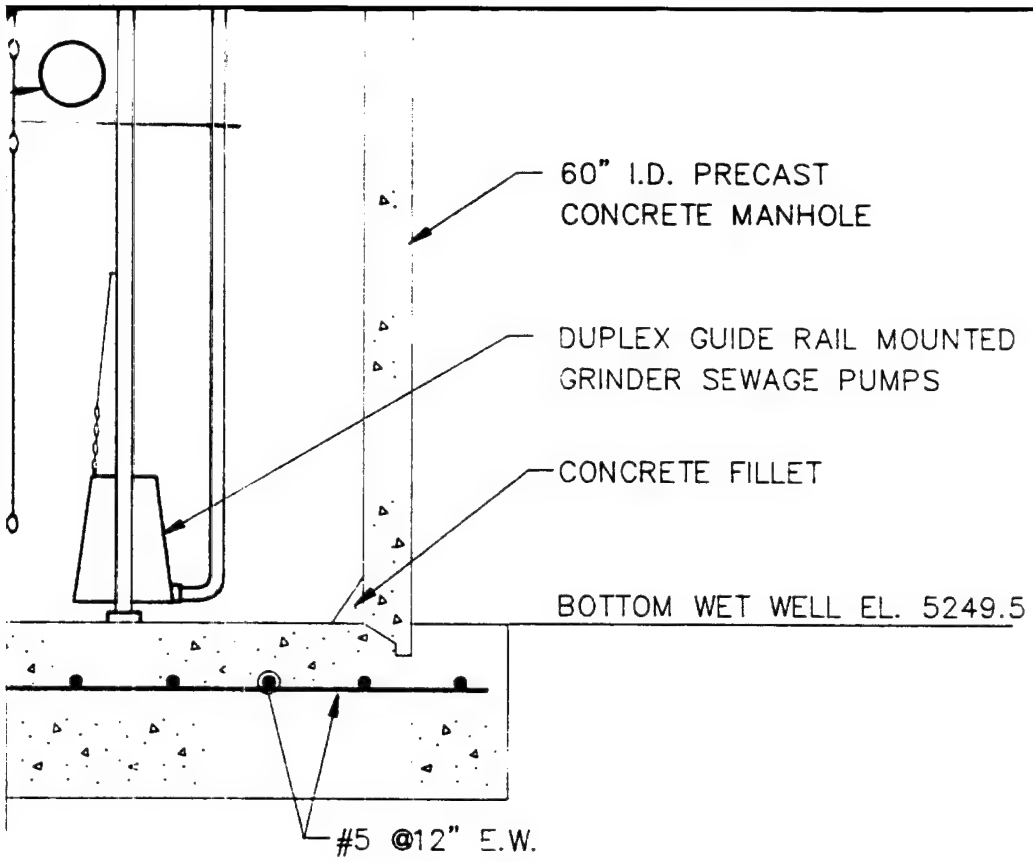
C

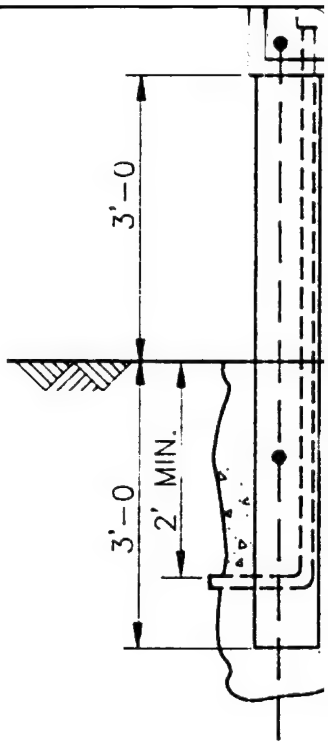
SECTION

1/2" = 1'-0"

B

24"
TO
PLU





ON

A

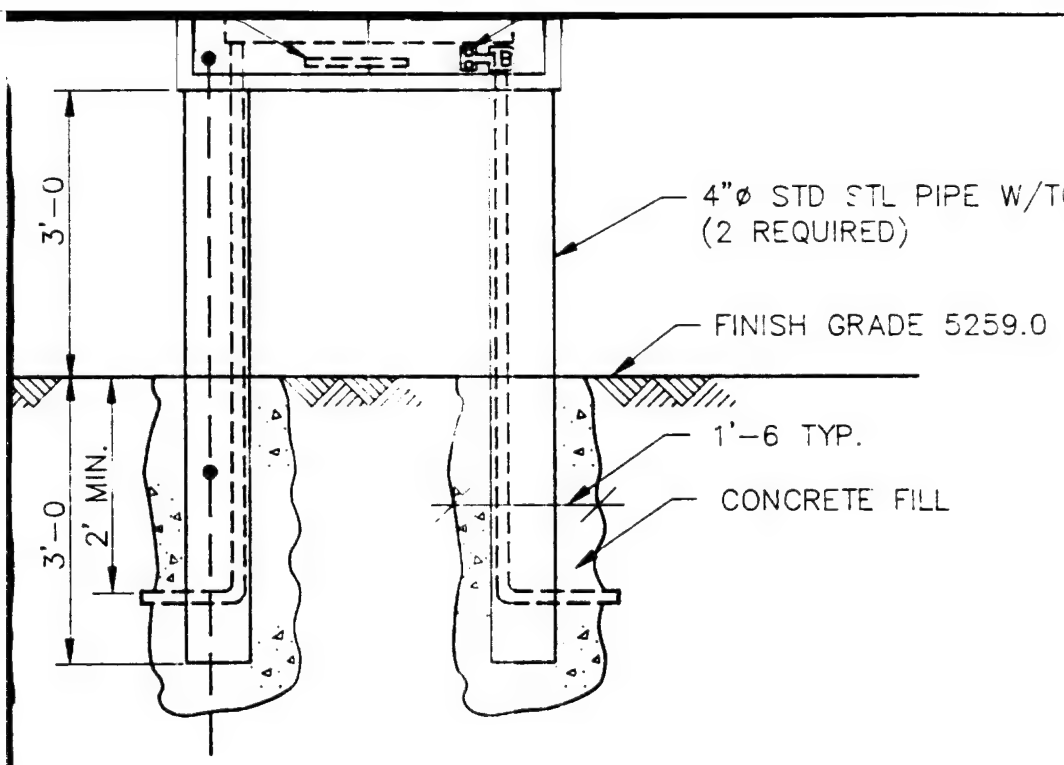
3 3

EQUIPMENT

1/2" = 1'-0"

24" x 48" BOXOUT W/ HINGED COVER
TO BE FIELD LOCATED DIRECTLY OVER
PLUG & CHECK VALVES

8" SEWER LINE
INV.(S) 5254.96



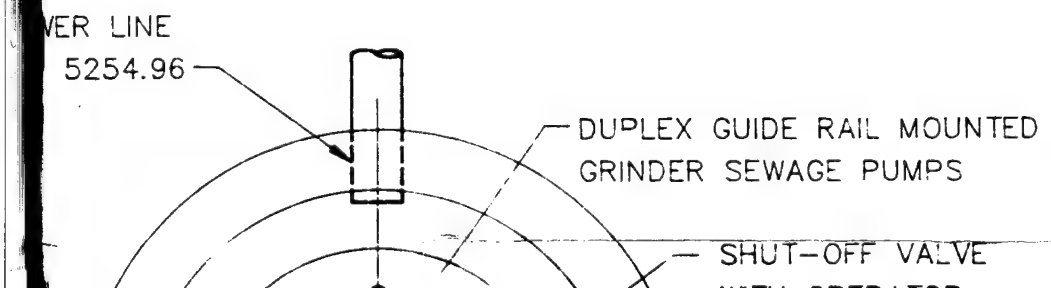
"RAM-
SEALA
EQUAL

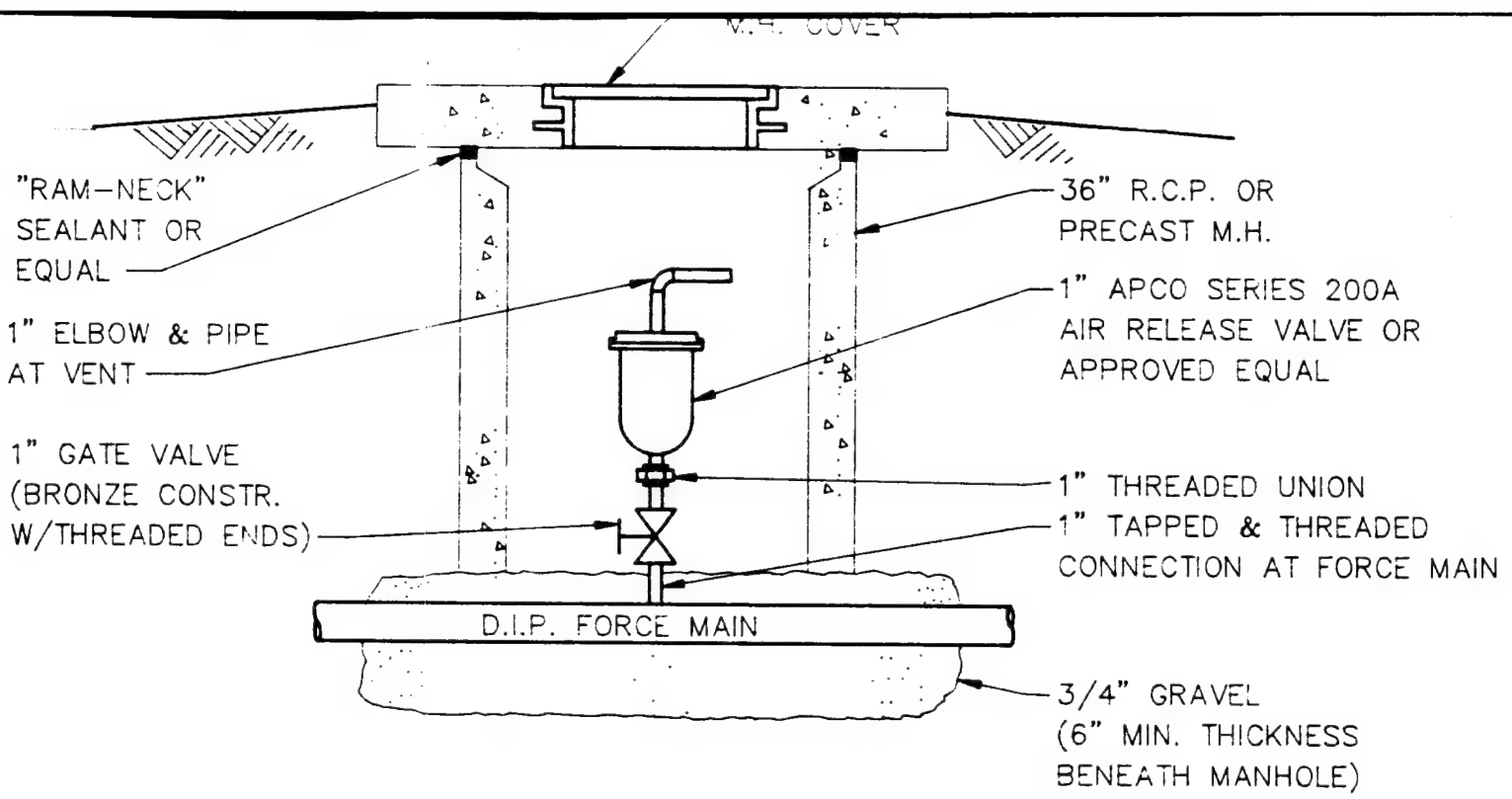
1" ELB
AT VEN

1" GAT
(BRON
W/THR

PMENT CABINET DETAIL

1'-0"





DETAIL 1

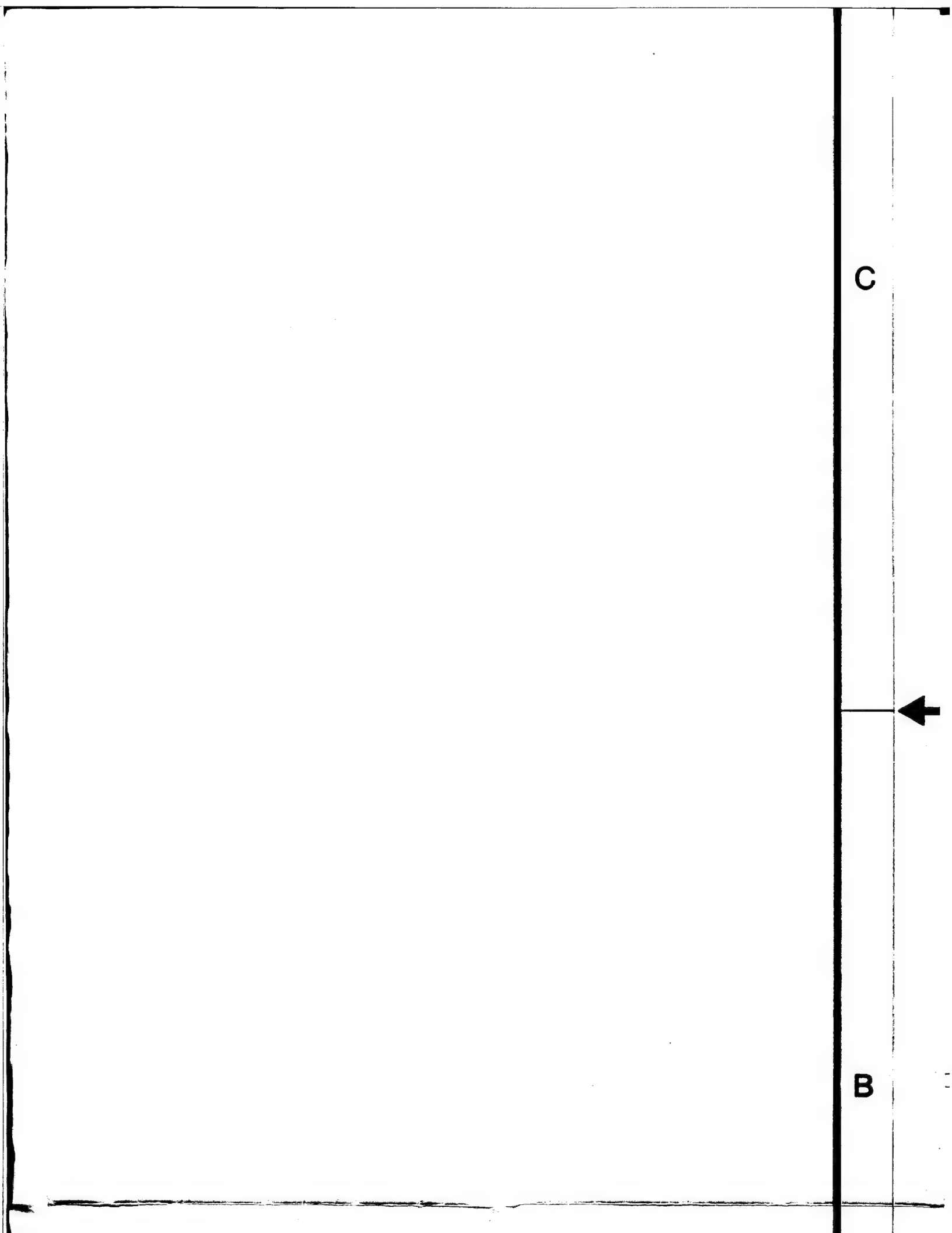
N.T.S. 3 | 3

C.P. OR
ST M.H.

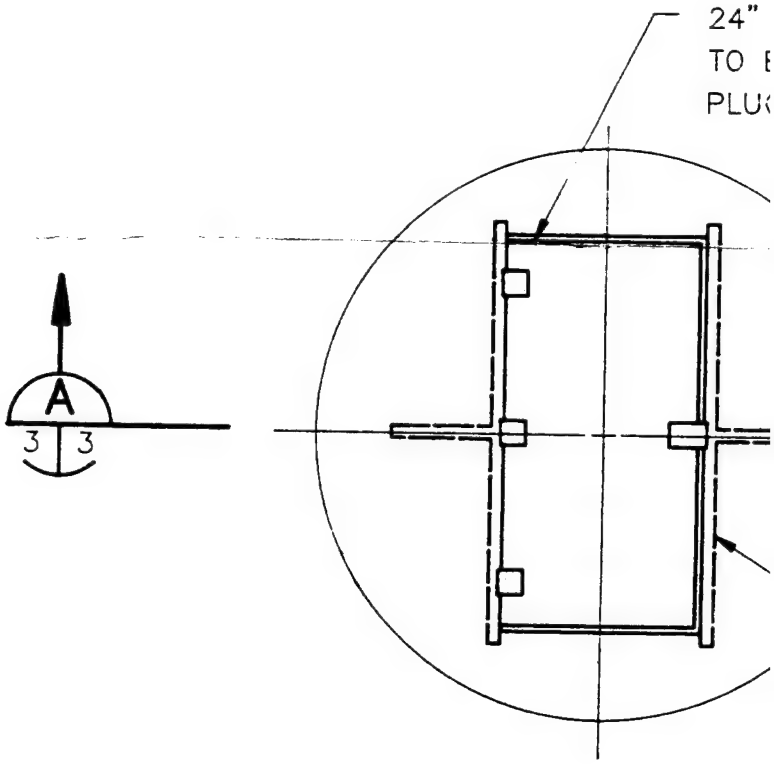
O SERIES 200A
LEASE VALVE OR
VED EQUAL

EADED UNION
PED & THREADED
CTION AT FORCE MAIN

RAVEL
N. THICKNESS
TH MANHOLE)


C
B

B



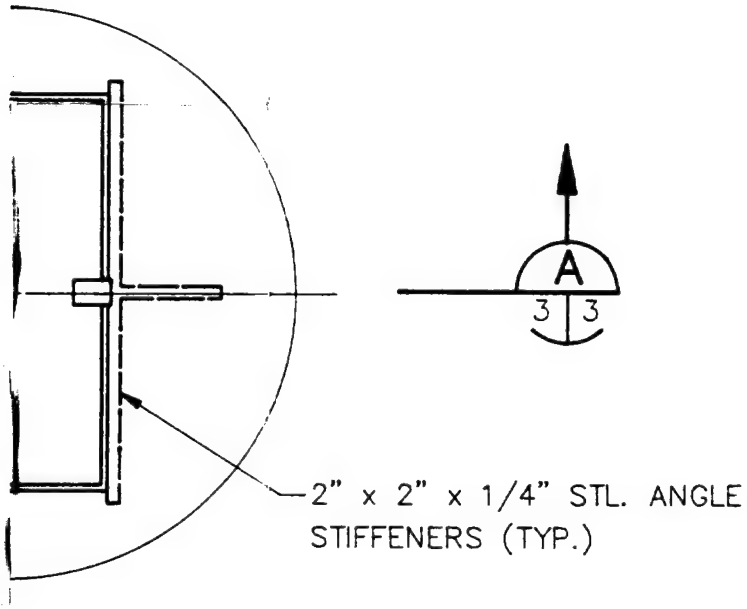
GRINDER SEWAGE LIF

1/2" = 1'-0"

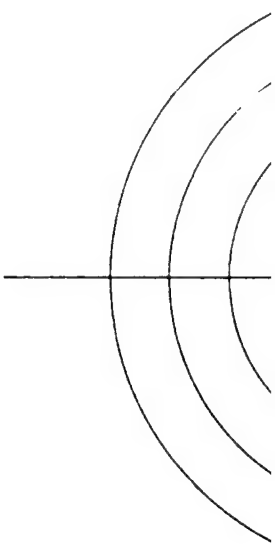
A

RMA1110-24MB011590

24" x 48" BOXOUT W/ HINGED COVER
TO BE FIELD LOCATED DIRECTLY OVER
PLUG & CHECK VALVES



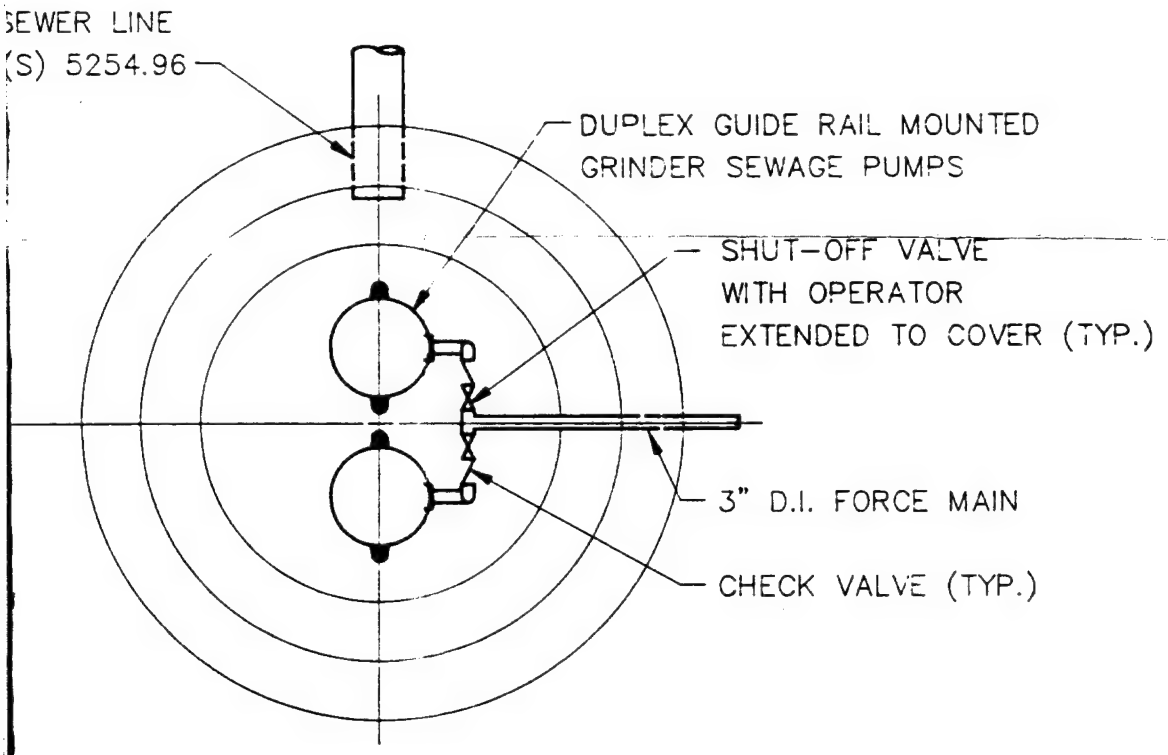
8" SEWER LINE
INV.(S) 5254.96



E LIFT STATION

SECTI

1/2" = 1'-0



SECTION B

1/2" = 1'-0"

3 | 3

$$ THINK VALUE ENGI	
	Revisions
Symbol	Descriptions
ROY F. WESTON, INC. DENVER, COLORADO	U.S
Designed by: MAA	ROCKY MOUNTA PROPOSED FC
Drawn by: JSO	D
Checked by:	
Reviewed by:	Scale: As Shown
	Spec. No.
Submitted by: Architect-Engineer	Contract No.

B

A

$$ THINK VALUE ENGINEERING $$

ol	Revisions: Descriptions	Date	Approved

Y F. WESTON, INC. DENVER, COLORADO	U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS OMAHA, NEBRASKA

ed by:
MAA

by:
SO

d by:

ROCKY MOUNTAIN ARSENAL, COLORADO
PROPOSED SANITARY SEWAGE
FORCE MAIN

DETAILS

ed by:

ted by:
ct-Engineer

Scale: As Shown		Sheet Reference Number. 3 OF 3	Date: JANUARY 1990
Spec. No.			Drawing Code:
Contract No.			

HEALTH & SAFETY PLAN

NEW SANITARY SEWER CONSTRUCTION

INTRODUCTION

This Health and Safety Plan provides guidance and establishes procedures for the installation of a new sewer line and related activities at the Rocky Mountain Arsenal, Denver, Colorado. The intention of the plan is to establish a safety policy and general standards, and to provide the framework for more specific safety requirements to be employed. This plan applies to all prime and subcontractor personnel working on this assignment and to visitors at project work locations. All affected personnel will be required to sign a statement to the effect that this document has been reviewed and understood prior to commencement of on-site activities and/or visits to the work location.

SECTION 1.0

PROJECT BACKGROUND

An existing sewer line in Section 35 and 36 of the RMA has been identified as being a source for migration of contaminants from previous South Plants operations. The South Plants from the early 1940's until the 1970's produced military and industrial chlorinated chemical products such as mustard gas and organo-chloride pesticides. Product compounds, intermediates, and by-products have been leached into the South Plants ground water and may have entered the sewer line through infiltration during periods of high ground water. The existing sewer line will be plugged and grouted after construction of a new sewer line serving the same area. This HASP defines the hazards and risks associated with the construction of a new sewer line. It also establishes specific health and safety requirements and procedures for this activity. This plan is designed to comply with OSHA regulations 29 CFR 1910.120, Environmental Protection Agency (EPA) Orders 1420.2 and 1440.3, and State Requirements. All activities must also meet OSHA construction standards 29 CFR 1910.26.

SECTION 2.0

SCOPE OF WORK

This HASP is developed to cover activities involved in the construction of a sewer line from the Fire Station to Building 111. This will consist of trenching to a depth of 5 ft, laying steel pipe, sealing the joints of the pipe, and backfilling the trench after the pipe is in place. The sewer line will be constructed through soil potentially contaminated with numerous organic and inorganic materials very likely in low concentrations. There are no recognized contaminated areas along the construction route other than the chemical sewer crossing zone. Hazards, in addition to those associated with the potential chemical contaminant in this work will include potential exposure to biological hazards such as bubonic plague and the physical hazards associated with construction, weather conditions and terrain.

SECTION 3.0

HAZARD IDENTIFICATION AND RISK ASSESSMENT

The hazards classes to be encountered with construction of the new sewer line in the South Plant includes chemical contaminants, biological hazards and physical hazards.

This section describes those hazards and determines the likelihood of exposure with concurrent or subsequent adverse effects.

3.1 PHYSICAL HAZARD ASSESSMENT

Accidents involving physical hazards can directly injure workers. Construction projects have their own variety of potential physical hazards, including, but not limited to heavy equipment use, excavation/trenching operations, heat and cold stress disorders related to hard physical labor and confined space entry. Each of these topics are discussed in detail below.

3.1.1 Heavy Equipment Operation

Before any machinery or mechanized equipment is placed in use, it will be inspected and tested by a competent mechanic and certified to be in safe operating condition.

The employer will designate a competent person to be responsible for the inspection of all machinery and equipment daily and during use to make sure it is in safe operating condition. Test will be made at the beginning of each shift during which the equipment is to be used to determine that the brakes and operating systems are in proper working condition.

Preventative maintenance procedures recommended by the manufacturer will be followed.

Any machinery or equipment found to be unsafe will be deadlined and its use prohibited until unsafe conditions have been corrected.

Inspections or determinations of road conditions and structures will be made in advance to assure that clearances and load capacities are surface for the passing or placing of any machinery or equipment.

Machinery and mechanized equipment will be operated only by designated personnel. Equipment deficiencies observed at any time that affect their safe operation will be corrected before continuing operation.

Seats or equal protection will be provided for each person required to ride on equipment.

Getting off or on any equipment while it is in motion is prohibited.

Machinery or equipment requiring an operator will not be permitted to run unattended.

Machinery or equipment will not be operated in a manner that will endanger persons or property nor will unsafe operating speeds or loads be exceeded.

Equipment used for lifting sheet piles or personnel shall be used and maintained in strict accordance with manufacturers directions and applicable OSHA regulations.

Load limits will be visibly posted on all lifting devices.

Only operators will demonstrated competence shall be permitted to operate lifting devices.

Lifting machinery and all elements of equipment involved in lifting or supporting loads must be inspected prior to use and at a minimum monthly. Inspections must be performed by a competent persons and must be documented.

3.1.2 Trenching/Excavation

On January 2, 1990, a new Final Rule of the OSHA Construction Standard, Subpart P - Excavations, became effective. This new Final Rule was promulgated to replace existing regulations. Construction of the new sewer line in the South Plants must follow these regulations.

Hazards associated with excavating in trenching include:

- Subsidence or cave-in wells resulting in burial of workers in the excavation or falling of workers or equipment into the trench.
- Falls of workers or equipment during access or egress from or into open trenches.
- Accumulation of contaminants within the excavation.
- Contact with underground or overhead utilities.

The trench for the new sewer line will be approximately five (5) feet. At this depth, when workers are exposed to hazards of items 1 and 2 above, trenches must be protected from caving in by sloping or shoring designed by a competent person. Sloping, when used as protection, must be designed to meet the stability characteristics of the soil. It is anticipated that sloping will be used in the new sewer construction.

All surface encumbrances such as debris, structures, etc., must be removed or stabilized from falling into the trench.

Soils removed from the trench must be placed at least two (2) feet from all tools, and other loose equipment, when not in use must be stored at least two (2) feet from the edge of the trench or otherwise effectively secured to prevent falling into the trench.

Equipment used in the excavation must be operated according to Section 3.1.1.

No person may enter work at the foot of the face or near the edge of the trench until **the Site Health and Safety Coordinator has inspected** and determined whether sloping or shoring is required to protect against cave-in or subsidence and the appropriate protection has been installed.

Trench and excavations must be inspected regularly by competent persons to ensure that changes in temperature, precipitation, shallow ground water, over burden or nearby building weight, vibration or nearby equipment operation has caused weakening of sides, faces and floors and that protection is being maintained.

Sufficient ramps or ladders must be provided to trenches or excavations to allow quick egress. Ladders may be placed no more than 25' apart, must be secured from shifting and must extend at least three feet above the landing point. Use, construction and maintenance of ladders must conform to ladder safety requirements.

Access to trenching areas must be controlled and limited to those persons who are authorized. Prior to entering a trench or excavation, workers must notify the site supervisor, site health and safety coordinator and nearby equipment operators whose activities could affect the trench or excavation.

If trenches or excavations are near walkways or roadways, guards or warning barriers must be placed to alert pedestrians and drivers of the presence of the trench or excavation.

Workers may not work under loads being handled by excavating or lifting equipment.

If possible, trenches or excavations should be covered or filled in when unattended. Otherwise, strong barriers must be placed around the trench or excavation and lighting must be provided at night if the trench or excavation is near walkways or roadways.

There are no underground or overhead utilities known to be in the proposed excavation route for the new sewer line with the exception of a chemical waste sewer line which is no longer in use and electrical overhead lines that are identified in the project plans. The sewer line will be located and special precautions identified under chemical hazards assessment, Section 3.2 of this part.

3.1.2 Confined Space Entry

A confined space is any space having a limited means of egress, which is subject to the accumulation of toxic of flammable contaminants or has an oxygen deficient atmosphere. Construction of the new sewer line is not expected to involve continued spacer entry unless entry must be made to an existing manhole. A confined space entry permit (CSEP) will be initiated by the Site Safety Supervisor of personnel who are to enter into or work a confined space. The CSEP will be completed by the personnel involved in the entry and approved by the SHSC before personnel will be permitted to enter the confined space. The CSEP shall be valid only for the performance of the work identified and for the location and time specified. The beginning of a new shift or change of personnel will require the issuance of a new CSEP.

3.1.4 Inclimate Weather

Heat, rain, cold, snow, ice and lightning are natural phenomena which complicate work activities and add or increase risk. Much of the responsibility for protection from inclement weather hazards falls upon the Site Health and Safety Coordinator (SHSC). The SHSC must recognize the inclement weather hazards affecting site for which he is responsible and complete the pre-site activity risk assessment when inclement weather occurs. The SHSC must

recognize which weather conditions affect instrument and Personal Protective Equipment function and constantly remind site workers of the effects and need for more careful attention to check-out, donning and doffing and monitoring of function and integrity. The SHSC must make decisions on the proper safety procedures to use if work must continue or to stop work if the risk is too great.

3.1.4.1 Heat Stress

Heat Stress Prevention and Monitoring

Heat stress may occur at any time work is being performed at elevated temperatures. Wearing of chemical protective clothing, which may result in decreasing natural body ventilation, increases the risk of heat stress.

If the body's physiological processes fail to maintain a normal body temperature because of excessive heat, a number of physical reactions can occur, ranging from mild (such as fatigue, irritability, anxiety, and decreased concentration, dexterity, or movement) to fatal. Because heat stress is one of the most common and potentially serious illnesses at hazardous waste sites, regular monitoring and other preventative measures are vital.

Site workers must learn to recognize and treat the various forms of heat stress. The best approach is preventative heat stress management. In general:

- Have workers drink 16 ounces of water before beginning work, such as in the morning or after lunch. Provide disposable 4- ounce cups, and water that is maintained at 50 - 60°F. Urge workers to drink 1 to 2 of these cups of water every 20 minutes for a total of 1 to 2 gallons per day. Provide a cool area for rest breaks. Discourage the intake of coffee during working hours. Monitor for signs of heat stress.
- Acclimate workers to site work conditions by slowly increasing workloads, i.e., do not begin site work activities with extremely demanding activities.
- Provide cooling devices to aid natural body ventilation. These devices, however, add weight and their use should be balanced against worker efficiency. An example of a cooling aid is long cotton underwear which acts as a wick to absorb moisture and protect the skin from direct contact with heat-absorbing protective clothing.

- o In extremely hot weather, conduct field activities in the early morning and evening.

- o Ensure that adequate shelter is available to protect personnel against heat as well as cold, rain, snow, etc. which can decrease physical efficiency and increase the probability of both heat and cold stress. If possible, set up the command post in the shade.

- o In hot weather, rotate shifts of workers wearing impervious clothing.

- o Good hygienic standards must be maintained by frequent changes of clothing and showering. Clothing should be permitted to dry during rest periods. Persons who notice skin problems should immediately consult medical personnel.

The following is a discussion of specific results of heat stress:

1.0 Heat Stroke

Heat stroke is an acute and dangerous reaction to heat stress caused by a failure of heat regulating mechanisms of the body; the individual's temperature control system that causes sweating stops working correctly. Body temperature rises so high that brain damage and death will result if the person is not cooled quickly.

- o Symptoms - Red, hot, dry skin, although person may have been sweating earlier; nausea; dizziness; confusion; extremely high body temperature; rapid respiratory and pulse rate; unconsciousness or coma.

- o Treatment - Cool the victim quickly. If the body temperature is not brought down fast, permanent brain damage or death will result. Soak the victim in cool, but not cold water; sponge the body with cool water or pour water on the body to reduce the temperature a safe level (102°F). Observe the victim and obtain medical help. Do not give coffee, tea, or alcoholic beverages.

2.0 Heat Exhaustion

Heat exhaustion is a state of very definite weakness or exhaustion caused by the loss of fluids from the body. The condition is much less dangerous than heat stroke, but it nonetheless must be treated.

- o Symptoms - Pale, clammy, moist skin; profuse perspiration and extreme weakness. Body temperature is normal, pulse is weak and rapid, breathing is shallow. The person may have a headache, may vomit, and may be dizzy.

- o Treatment - Remove the person to a cool, air conditioned place, loosen clothing, place in a head-low position and provide bed rest. Consult physician, especially in severe cases. The normal thirst mechanism is not sensitive enough to ensure body fluid replacement. Have patient drink 1 to 2 cups of water immediately, and every 20 minutes there after until symptoms subside. Total water consumption should be about 1 to 2 gallons per day.

3.0 Heat Cramps

Heat cramps are caused by perspiration that is not balanced by adequate fluid intake. Heat cramps are often the first sign of a condition that can lead to heat stroke.

- o Symptoms - Acute painful spasms of voluntary muscles, e.g., abdomen and extremities.
- o Treatment - Remove victim to a cool area and loosen clothing. Have patient drink 1 to 2 cups of water immediately, and every 20 minutes thereafter until symptoms subside. Total water consumption should be 1 to 2 gallons per day.

4.0 Heat Rash

Heat Rash is caused by continuous exposure to heat and humid air and aggravated chafing clothes. The condition decreases ability to tolerate heat.

- o Symptoms - Mild red rash, especially in areas of the body that come into contact with protective gear.
- o Treatment - Decrease amount of time in protective gear and provide powder to help absorb moisture and decrease chafing.

5.0 Heat Stress Monitoring and Work Cycle Management

For strenuous field activities that are part of on-going site work activities in hot weather, the following procedures shall be used to monitor the body's physiological response to heat, and to manage the work cycle, even if workers are not wearing impervious clothing. These procedures are to be instituted when the temperature exceeds 70°F.

Measure Heart Rate - Heart rate should be measured by the radial pulse for 30 seconds as early as possible in the resting period. The HR at the beginning of the rest period should

not exceed 110 beats/minute. If the HR is higher, the next work period should be shortened by 33%, while the length of the rest period stays the same. If the pulse rate still exceeds 110 beat/minute at the beginning of the next rest period, the following work cycle should be further shortened by 33%. The procedure is continued until the rate is maintained below 110 beats/minute.

Measure Body Temperature - When ambient temperatures over 90°, body temperatures should be measured with a clinical thermometer as early as possible in the resting period. Oral temperature (OT) at the beginning of the rest period should be shortened by 33%, while the length of the rest period stays the same. If the OT exceeds 99.6°F at the beginning of the next rest period, the following work cycle should be further shortened by 33%. The procedure is continued until the body temperature is maintained below 99.6°F.

Physiological Monitoring Schedule - The following Suggested Frequency of Physiological Monitoring Schedule for Fit and Acclimated Workers shall be used as a guideline:

Temperature	(Level D)	(Level C)
90°F (32.2°C) or above	After each 45 minutes of work	After each 15 minutes of work
87.5°F (30.8° - 32.2°C)	After each 60 minutes of work	After each 30 minutes of work
82.5°-87.5°F (28.1° - 32.2°C)	After each 90 minutes of work	After each 60 minutes of work
77.5°-82.5°F (25.3° - 28.1°C)	After each 120 minutes of work	After each 90 minutes of work
72.5°-77.5°F (22.5° - 25.3°C)	After each 150 minutes of work	After each 120 minutes of work

Measure the air temperature with a standard thermometer. Estimate fraction of sunshine by judging what percent the sun is out.

100% sunshine = no cloud cover = 1.0

50% sunshine = 50% cloud cover = 0.5

0% sunshine = full cloud cover = 0.0

Adjusted temp. = actual temp. + 13 X (% sunshine factor).

The length of work period is governed by Frequency of Physiological Monitoring. The length of the rest period is governed by physiological parameters (heart rate and oral temperature). For example, if an individual's heart rate exceeds 110 beats/minute at the beginning of the rest period, that individual will remain on rest-time until his/her heart rate drops well below 110 beats/minute and their next work period (=duration of time before suggested physiological monitoring) is decreased by 33%.

3.1.4.2 Cold Stress

The potential for cold stress is a particular concern when field activities are performed while air temperatures at the site are below 40 degrees F. If winds are blowing at 5 mph or greater and/or the weather is damp or wet, cold stress is even more of a potential hazard. Precautions that will be taken to prevent cold stress include wearing cold-protective clothing appropriate for the level of cold and physical activity, changing clothing if it becomes wet, and establishing a work/warming regiment. Cold-protective clothing will include layering of garments and use of gloves and hats. The warming breaks should be taken in a warm location if at all possible; this can include improvising a wind break shelter at the site. During warming breaks taken in the site support zone, warm, sweet beverages and not soups should be consumed to provide calories and fluids. Drinking coffee or other caffeinated beverages is not recommended.

Cold stress, if not prevented, can result in frostbite and hypothermia. Ignoring the signs any symptoms can be life-threatening. Prevention is the key. As a preventative measure, body core temperature must not drop below 96.8 degrees F. Pain in the extremities is the first early warning of cold stress. Severe shivering sets in when body core temperature has dropped to 95 degrees F. If this occurs, work will stop immediately and the affected worker(s) will take a warming break of sufficient duration that the cold stress signs and symptoms are gone.

Additional signs of cold stress include deterioration of physical coordination, slurred speech, and faulty judgement.

3.1.4.3 Lightning

Lightning represents a hazard of electrical shock which is increased when working in flat open spaces, elevated work places are working near tall structures or equipment. Stopping work in open areas, around drill rigs or pile driver which may attract lightening, on or in water and in elevated work places when lightning strikes are sighted or thunder is heard near a work site.

3.1.5 Noise

Construction activities invariably pose the risk of workers exposure to noise. In activities involved in construction of the new sewer line, the most likely source of noise exposure will be heavy equipment and internal construction engine operation and possibly use of power tools.

A hearing conservation program including informing workers, second level assessment and andrometer testing (as part of the medical certification program) will be implemented if sound level assessments indicate workers experience to 85 dba or greater. If sound level assessment reaches dba levels in excess of 90, hearing protection will be required if exposure duration exceeds the OSHA regulation values.

3.2 CHEMICAL HAZARD ASSESSMENT

Chemical hazards which may be encountered during the new sewer line construction activity are directly related to the chemical and physical properties of the compounds that are present in the excavated soil and ground water which may be encountered during construction.

The compounds in Table 3.1 have been identified in soil and ground water at the Rocky Mountain Arsenal. Attachment 1 provides compound specific information.

In most of the new sewer line construction, work will be in soil not expected to contain these contaminants. However, at one point in construction, the new sewer line will cross an existing waste chemical sewer line which is expected to be intact and may contain residual waste. As this is not certain, extra precautions will be taken when approaching this area. For most of the workers, potential for exposure to physio chemical or toxic hazards are expected to be unlikely.

Presence of chemicals in concentrations which are by definition flammable, corrosive or reactive is highly unlikely, however, initial and periodic monitoring for combustible atmosphere will be performed during intrusive activities. Activity levels are established to define monitoring in Section 5. Changes in personal protection will be based on changes from background conditions.

Based on knowledge of ground-water levels of contaminants in soil and ground water in the work area, it is likely that any airborne levels of contaminants would be only a fraction of any applicable PEL or TLV, even in the vicinity of the waste chemical sewer line.

Even though no significant airborne level of contaminants are anticipated, monitoring will be performed for toxic vapors. Action guidelines are established to define protection change based on changes in airborne contaminant levels. The greatest risk of toxic exposure would be from skin contact to a sensitive individual and ingestion of contaminants adhering to the hands of workers when they eat or drink. Protective clothing, gloves and boots will be used to minimize these risks as the old sewer line is approached.

3.3 BIOLOGICAL HAZARD ASSESSMENT

The only known biological hazard to workers at the RMA is the plague. The Arsenal's prairie dog population carries fleas that are infected with the plague. Workers should avoid any contact with dead animals. By taping pants to the boots, the flea cannot come in contact with the worker's legs.

3.4 REGULATORY STATUS

The RMA must comply with both Federal and State regulatory requirements. The Federal regulatory requirements include CERCLA as amended by SARA, RCRA, OSHA, and DOD. State requirements for RCRA and OSHA are also included in the regulatory status of RMA. Since RMA is on the National Priorities List (NPL), and under CERCLA authority for clean-up and remediation, additional federal and state regulatory requirements may be applicable, or relevant and appropriate.

TABLE 3-1

POTENTIAL CONTAMINANTS

Aldrin/Dieldrin
Dicyclopentadiene (DCPD)
Dibromochloropropane (DBCP)
Diisopropylmethylphosphonate (DIMP)
Endrin
Chloroform
1,2-Dichloroethane
1,1-Dichloroethene
T-1,2-Dichloroethene
1,1-Dichloroethane
Benzene
Chlorobenzene
DDT
DDE
Carbon Tetrachloride
Methylene Chloride
1,1,1-Trichloroethane
1,1,2-Trichloroethane
Isodrin
Toluene
Ethylbenzene
M-xylene
O&P-xylene
Trichloroethene
Tetrachloroethene
1,4-Oxathiane
1,4-Dithiane
Arsenic
Mercury
Lead
Cadmium
Zinc
Hydrazine
Nitrosodimethylamine

SECTION 4.0

KEY PERSONNEL/IDENTIFICATION OF HEALTH AND SAFETY PERSONNEL

4.1 KEY PERSONNEL

Listed below are personnel with RMA and WESTON which are key players regarding the activities at this site. Also identified are each key persons roles and responsibilities with site.

	RMA Representative	Address	Telephone
Tim Kilgannon	Environmental Energy	72nd & Quebec St. Commerce City, CO 80222	(303) 289-0289

Roles and Responsibilities: Shall be Task Manager and responsible for the interim response activities conducted at this site shall ensure all contractors complete and fulfill all contract requirements.

WESTON Representatives	Address	Telephone
Paul Warbington Senior Project Manager	215 Union Blvd., Suite 550 Lakewood, CO 80228	(303) 980-6800

Roles and Responsibilities: Shall manage manhole-sewer line closure activities. Shall assure proper health and safety programs which are functional according to the designed health and safety plans. Assure that all regulations and policies are being followed and that the potential hazards are presented before work begins.

WESTON Representatives	Address	Telephone
Frank Kabot Regional Safety Officer	215 Union Blvd., Suite 550 Lakewood, CO 80228	(303) 980-6800

Roles and Responsibilities: Shall audit the health and safety related activities at this site to ensure compliance with the approved HASP.

4.2 SITE SPECIFIC HEALTH AND SAFETY PERSONNEL

The On-Site Health and Safety Officer (OSHSO) for activities to be conducted at this site is _____.

The Site Health and Safety Coordinator (SHSC) has total responsibility for ensuring that the provisions of this Site HASP are adequate and implemented in the field.

Changing field conditions may required decisions to be made concerning adequate protection programs. Therefore, the personnel assigned as SHSC's are experienced and meet the additional training requirements specified by OSHA in 29 CFR 1910.120.

SECTION 5.0

HEALTH AND SAFETY PROCEDURES

5.1 TASK SPECIFIC SITE BRIEFING

Prior to beginning work on the construction of the new sewer line, all employees will receive a formal preparation of the site specific Health and Safety Plan. This training will be the responsibility of the On-Site Health and Safety Officer. The OSHSO will also present regularly scheduled safety meetings and daily safety briefings to key workers current with requirements and any changes in conditions or procedures.

5.2 LEVEL OF PROTECTION

The new Sewer Line Construction is only expected to encounter hazardous conditions during construction over and around the chemical waste line. It is expected that the waste line is intact and previous contents remain contained. However, accidental breach of the waste line during construction activities could release chemical residuals into the environment. Consequently, it has been determined that within 10 feet of the waste line that constant direct reading PID or FID monitoring of the dirt as it is removed from the trench, shall be required. If Volatile Organic Compounds (VOCs) are detected, an increase in the level of protection from modified Level D to Level C is required by those individuals involved in this activity. When VOCs are detected at 5 units above initial readings on increase of the level of protection from Level C to Level B. See Action Levels in Table 5-1.

The objective of personnel protective equipment (PPE) specified for the use during the new sewer line construction is to shield individuals from the chemical hazards associated with the chemical waste line. Based upon the available information relating to compounds detected in the ground water and the surrounding soils as well as their likelihood for skin contact, the following modified Level D is recommended:

- Hard hats
- Safety glasses with side shields
- Hearing plugs or muffs (if sound level assessment required)
- Whole body, Saran coated Tyvek
- Latex rubber inner gloves
- Leather/cotton gloves (optional)
- Steel toed boots
- Latex rubber outer boots (optional)

Level B protection shall include all level C equipment and substitute pressure demand supplied air breathing apparatus for the full face respirators.

Level C protection shall include all of the above and also include the following:

- outer butyl gloves
- full face respirators with GMC-H

5.3 FIELD MONITORING INSTRUMENTS

Air monitoring will be conducted periodically using a combustible O_2 meter and an OVA-128 Foxboro, while trenching and while laying new pipe. These air monitoring frequencies and locations will be increased as work approaches the waste chemical sewer line.

Action levels are presented in Table 5.1. These action levels signify a concentration or criteria at which appropriate field action must be taken. This action can be in the form of upgrading to respiratory protection, a dermal protection increase or evacuation of the construction area. Level C and Level B protection are defined in Section 5-2.

When approaching within ten (10) feet of the chemical waste line, each backhoe bucket of soil shall be monitored with an OVA. Should any three consecutive buckets produce

readings greater than the background level. All personnel in the work area shall upgrade personal protection to level C. Should the readings exceed the limits in Table 5-1, a further upgrade to level B shall be required. When readings in ten consecutive buckets are below the limits established in Table 5-1, a down grade in personal protection may be recommended by OSHSO.

TABLE 5-1

ACTION LEVELS

1) OVA or HNU

> Background - 5 units	-	Level C required
> 5 units - 20 units	-	Level B required
> 20 units	-	Stop work.

2) Combustible Gas

0 - 10% LEL	-	Continue to work and monitor periodically.
10 - 25% LEL	-	Monitor continuously, use extreme caution.
> 25% LEL	-	Leave area.

3) Oxygen

< 19.5%	-	Stop work. Level B and confined space entry procedures required.
> 21% - 25%	-	Stop work. Review area for presence of oxidizer. Continue only with extreme caution.
> 25%	-	Stop work.

3) Semivolatile Organic Compounds

Need based upon environmental conditions favoring dust deposition. Filtration sampling utilizing personal and high-volume samplers equipped with size selective classifier (cyclone) to be used at the discretion of the OSHSO.

Respirable dust level - must be below the most restrictive TLV of the components x % presence x full face-piece protection factor of 50.

5.5 AIR SAMPLING

An air sampling program will be instituted during the installation of the new sewer line. Table 5-2 lists the contaminants and sampling formation. Sampling will be conducted at two locations or in the area selected to assess the worst case situation during initial stages (first or second day) and once during work in the vicinity of the crossing of the waste chemical line.

All sampling and analysis will be accomplished according to NIOSH methods.

Sampling will be performed by or under the direction of a competent Industrial Hygienist.

TABLE 5-2

CONTAMINANT	MEDIA	FLOW RATE (L/MIN)	VOLUME (L)	GROUP
Trichloroethylene	Charcoal COC 100mg/50mg	0.2	15	A
Carbon Tetrachloride	Charcoal COC 100mg/50mg	0.2	15	A
Tetrachloroethylene	Charcoal COC 100mg/50mg	0.2	15	A
Chloroform	Charcoal COC 100mg/50mg	0.2	15	A
Chlorobenzene	Charcoal COC 100mg/50mg	0.2	15	A
Methyl Isobutyl Ketone	Charcoal COC 100mg/50mg	0.2	15	A
Methylene Chloride	2 Charcoal COC 100mg/50mg	0.2	1.5	B
Dibromochloropropane (DBCP)	Charcoal/Pet.	0.2	7	C
Benzene	Charcoal COC 100mg/50mg	0.2	20	D
Xylene	Charcoal COC 100mg/50mg	0.2	20	D
Ethylbenzene	Charcoal COC 100mg/50mg	0.2	20	D
Cadmium	Mixed Cellulose Ester	1.5	720	E
Copper	Mixed Cellulose Ester	1.5	720	E
Lead	Mixed Cellulose Ester	1.5	720	E
Arsenic	Mixed Cellulose Ester	1-2	960	F
Chlorodane	PUF	3	1,000	G
Aldrin	PUF	3	1,000	G
Dieldrin	PUF	3	1,000	G
Endrin	PUF	3	1,000	G
DDT	PUF	3	1,000	G

SECTION 6.0

MEDICAL SURVEILLANCE REQUIREMENTS

All project staff and subcontractors who will be performing field work in areas either suspected or known to be contaminated will be required to participate in a medical surveillance program. For all site personnel, a release for work will be verified by the Site Health and Safety Coordinator (SHSC) before an employee or subcontractor can begin on-site activities.

The physical exam will be administered prior to the onset of any field work and upon termination of employment or field involvement. Episodic examinations may also be administered, at the discretion of the SHSC.

6.1 OBJECTIVES

The medical surveillance program has been designed specifically to address those activities associated with invasive operations conducted at the Rocky Mountain Arsenal. All physical examinations falling under the program will be administered by a licensed physician.

In general, the principal objectives of the medical surveillance program are to:

- Provide respirator certification as required under 29 CFR 1910.134.
- Determine an individual's ability to perform work while wearing protective equipment.
- Assist in evaluating the adequacy of the personal protective equipment prescribed.
- Establish a physiological baseline necessary to assess the degree and/or effects of exposure to hazardous materials.
- Provide data for future epidemiological studies and evaluations.

6.2 MEDICAL INFORMATION DISCLOSURE AND CONFIDENTIALITY

The personal medical information obtained through the medical surveillance program shall be treated as strictly confidential, and may be released only through adherence to the corporate guidelines.

Consistent with this policy, all personnel will be requested to complete a "Medical Record Release Authorization" form and submit it to the examining physician with a completed medical history questionnaire at the time of the exam. With this release, the examining physician will be able to inform each employe and project management of an individual's physical status and ability to perform work on the project site with or without any specified work restrictions.

6.3 SITE PERSONNEL AND CERTIFICATION STATUS

A. WESTON

Name	Title	Task(s)	Medical Current a.	Fit Test Current Qual. b.	Fit Test Current Quant. b.	Training Current c.	Certification Level or Description
1.							
2.							
3.							
4.							
5.							
6.							
7.							
8.							
9.							
10.							

C. Subcontractor

Name	Title	Task(s)	Medical Current a.	Fit Test Current Qual. b.	Fit Test Current Quant. b.	Training Current c.	Certification Level or Description
1.							
2.							
3.							
4.							
5.							
6.							

SECTION 7.0

EMERGENCY CONTACTS AND PHONE NUMBERS

Agency	Contact	Phone Number
Local Medical Emergency Facility		(303) 363-7200
WESTON Medical Emergency Contact	AGATHA	(513) 421-3063
WESTON Health and Safety	Frank Kabot	(303) 980-6800
Fire Department	RMA - on site	(303) 289-0187
Police Department	Post Security	(303) 289-0369
On Site Coordinator		
Site Telephone	WSI	(303) 287-6884
Nearest Telephone	WESTON	(303) 980-6800

LOCAL MEDICAL EMERGENCY FACILITY(S)

Name of Hospital: Aurora Presbyterian

Address: 700 Potomac Street Phone No.: (303) 363-7200

Type of Service: Physical Trauma & Chemical Exposure and Available 24 Hours

Route to Hospital: (Attach Map) Exit RMA through West Gate to Quebec Street; South to I-70 East; I-70 to I-225 South to 6th Avenue. Right on 6th Avenue West to Potomac Street. Potomac North to Aurora Presbyterian.

Travel Time From Site (Minutes): 20

Distance to Hospital (Miles): 15

Name/No. of 24 Hr. Ambulance Service: (303) 289-0187

SECTION 8.0

SITE PERSONNEL TRAINING AND CERTIFICATION REQUIREMENTS

Access to project areas, within the scope of WESTON's control and the Site Health and Safety Plan (HASP), is limited to those persons who met WESTON Certification Requirements. All persons to whom this HASP applies must be informed of site hazards, Standard Procedures and site specific requirements for personnel protection.

Access to this site shall be limited to those WESTON persons and Subcontractors certified by training, medical evaluation and Fit Testing per the Standard Practices and Subcontractor Services Agreements.

a)	Training (General):	All personnel, including visitors, entering the exclusion or contamination reduction zones must have certification of current training status in accordance with OSHA 29 CFR 1910, 1926 or 1910.120. Appendix A defines the WESTON Training Program and requirements for maintaining current status.
b)	Training and Qualifications:	Site manager and Site Health and Safety Coordinators (SHSC) must meet experience criteria and have additional training prior to being assigned to these positions. In addition to an 8-Hour Certification Course, Site Managers and SHSC's must have current First Aid and CPR status.
c)	Medical Monitoring Requirements:	All personnel, including visitors, entering the exclusion or contamination reduction zones must be currently certified as medically fit to work, and to wear a respirator, if required, in accordance with 29 CFR 1910, 1926 or 1910.120.
d)	Respirator Fit Testing:	All persons, including visitors, entering any area requiring the use or potential use of any negative pressure respirator must have had as a minimum, a qualitative fit test, administered in accordance with OSHA 29 CFR 1910.134 or ANSI within the last 12 months. If site conditions require the use of a full face negative pressure, air purifying respirator, employees must have had a quantitative fit test, administered according to OSHA 29 CFR 1910.1002, .1018 or .1025 within the last six months.

SECTION 9.0

DECONTAMINATION OF PERSONNEL AND EQUIPMENT

Personnel contact with contaminants will be minimized as far as can be reasonably achieved. Personnel and equipment that have been in contact with contaminated materials may carry residual contamination. Despite protective clothing, equipment, and good work practices, decontamination is necessary to prevent personnel exposure and migration of contaminants. Decontamination will be done under the direction of the Site Safety Coordinator. The work location will be divided into three distinct work zones. The work zones are as follows:

Zone 1: Exclusion Zone -- The zone where contamination does or could exist. All personnel entering this one must wear the level of protective clothing specified for that work area.

Zone 2: Contamination Reduction Zone -- Provides a transition zone between the Exclusion Zone and the Support Zone to prevent the spread of contaminants from the Exclusion Zone. Decontamination is performed in this zone.

Zone 3: Support Zone -- Area of work site considered to be non-contaminated located upwind of the Exclusion Zone. This is a storage area for support equipment and provides a point of personnel access and traffic control to the Exclusion Zone.

The following general guidelines will be used in the development of decontamination procedures:

- The level of decontamination will depend on the nature and magnitude of contamination, and the type of protective clothing.
- Personnel assisting in the decontamination activities will be attired in clothing to protect them from contamination released during the decontamination process.
- Under emergency conditions, decontamination procedures will be omitted and lifesaving measures initiated without delay if:
  - decontamination activities could aggravate or cause more serious health effects, or if
  - prompt lifesaving first aid and/or medical treatment is required.

Personnel decontamination for Level D protection will consist of washing hands and face with soap and water after leaving the exclusion zone and before eating or drinking.

Personnel in Level B protection will wash their outer gloves and boots with a solution of trisodiumphosphate, Alconox, and water followed by a tap water rinse. Personnel will also wash their hands and face after removing all protective clothing.

All personnel working at the RMA will change from personal clothing to work clothing prior to performing any work. Prior to leaving RMA each evening, personnel will shower and change. Field work clothing is not to be worn off the RMA.

All disposal coveralls, gloves, booties, etc. will be placed in drums, labeled, and given to the hazardous waste contractor at RMA. All waste from the exclusion zone will be considered hazardous waste and kept separate form other waste.

Heavy equipment will be decontaminated by moving equipment to the decontamination pad and cleaning with high pressure hot water. Liquid is to be transferred to the tank at the decontamination pad. Personnel performing the decontamination will be dressed in Level C attire with a face shield to protect from splashback.

SECTION 10.0

EMERGENCY RESPONSE

10.0 CONTINGENCY PLAN

The contingency plan identifies for the project staff the actions to be taken in the event of medical emergencies, fires, and explosions.

10.1 MEDICAL EMERGENCIES

Emergency medical treatment must be available and provided as quickly as possible when needed. This requires careful planning and a pre-determined sequence of events, a contingency plan, if it is to be effective, and meet regulatory requirements.

There must be at least one person on every site who has current certification in First Aid and CPR. If field teams are more than five minutes apart, each team must have a member current in First Aid and CPR.

There must be at least one approved First Aid Kit on every site. If work crews are out of line of sight with each other, each crew must have a First Aid Kit.

When work involves potential eye contact or exposure to chemical hazards, either contaminants, process materials or laboratory reagents, eye washes must be immediately available with minimum clean water flow duration of 15 minutes.

When the potential for chemical splash exists, safety showers with a minimum flow duration of 15 minutes must be immediately available.

There must be provisions for transportation of an ill or injured worker to the emergency medical facility if an ambulance service is unable to respond within ten minutes.

10.2 FIRES AND EXPLOSIONS

Fires and explosions must be responded to quickly and efficiently if control and minimization of risk is to be accomplished. The key to fire and explosion response is identification of risk, fire and explosion prevention plans, having a pre-designed response plan and training.

10.2.1 Fire and Explosion Risk Assessment

Fire and explosion potential exists when ignition sources are used in the vicinity of explosive, flammable or combustible materials and when chemicals interact. The Site HASP risk assessment must identify the potential for fires or explosions occurring on site, and appropriate Prevention and Response Plans must be implemented.

10.2.2 Fire and Explosion Prevention

Preventing fires and explosions is an integral part of a contingency plan. Prevention programs, if not totally successful, minimize the chance of occurrence, reduce the magnitude of a fire or explosion and allow quicker response. Fire prevention procedures include use of the "Hot Work" Permitting System, safe welding procedures, safe storage/use of flammable and explosive materials, smoking restriction policies, fire watches, vapor freeing/tank inerting, etc. These elements must be implemented as part of the basic HASP. Procedures are found in Part II of this Standard Plan.

All contacts and telephone numbers are listed in Section 7.0.

SECTION 11.0

HEALTH AND SAFETY PLAN APPROVAL/SIGN OFF FORM

Site Name: Rocky Mountain Arsenal WO#: 5300-01-03-0070

Work Location Address: 72nd and Quebec Street, Commerce City, Colorado 80022

I have read, understood, and agreed with the information set forth in this Health and Safety Plan (and attachments) and discussed in the Personnel Health and Safety briefing.

Site Safety Coordinator	Signature	Date
Name	Signature	Date
Name	Signature	Date
Name	Signature	Date
Name	Signature	Date
Name	Signature	Date
Name	Signature	Date
Name	Signature	Date
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Name	Signature	Date
Name	Signature	Date

ATTACHMENT 1

CHEMICAL, PHYSICAL, AND BIOLOGICAL PROPERTIES OF RMA CONTAMINANTS

ALDRIN/DIELDRIN

Summary

Aldrin degrades to dieldrin, which is very persistent in the environment. Both pesticides are carcinogenic in rats and mice and are teratogenic and reproductive toxicants. Aldrin and dieldrin cause liver toxicity and central nervous system abnormalities following chronic exposure. Both are also acutely toxic, with oral LD_{50} values of about 50 mg/kg. Both pesticides are very toxic to aquatic organisms and have been associated with large-scale kills of terrestrial wildlife in treated areas.

Background Information

Dieldrin is the 6,7-epoxide of aldrin and is readily obtained from aldrin under normal environmental conditions and by metabolism in animals.

CAS Number: Aldrin: 309-00-2
Dieldrin: 60-57-1

Chemical Formula: Aldrin: $C_{12}H_8Cl_6$
Dieldrin: $C_{12}H_8Cl_6O$

IUPAC Name:
Aldrin: 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4:5,8-exo-dimethanonaphthalene
Dieldrin: 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-endo,exo-1,4:5,8-dimethanonaphthalene

Chemical and Physical Properties

Molecular Weight: Aldrin: 365
Dieldrin: 381

Melting Point: Aldrin: 104°C
Dieldrin: 176 °C

Solubility in Water: Aldrin: 20/ ug/liter at 25°C
Dieldrin: 200 ug/liter at 25°C

Solubility in Organics: Soluble in most organic solvents

Log Octanol/Water Partition Coefficient: No data found; probably greater than 5 for both chemicals

Vapor Pressure: Aldrin: 2.31×10^{-5} mm at 20°C
Dieldrin: 2.8×10^{-6} mm at 20°C

Transport and Fate

Aldrin evaporates rapidly from aquatic environments and also probably from soil. Photolysis probably occurs in the atmosphere after volatilization. Adsorption, especially by organic materials, is also an important fate process for this chemical. Aldrin is bioconcentrated by aquatic organisms by a factor of 10^3 to 10^4. Biotransformation by aquatic organisms and biodegradation are also important fate processes.

The primary product of aldrin degradation is its epoxide, dieldrin. Photolysis of aldrin also produces small amounts of photoaldrin, photodieldrin, and a polymerization product. Dieldrin is considered to be at least as toxic as aldrin and is quite persistent in the environment. Therefore, transformation of aldrin represents only a change of state and not detoxification of the chemical.

Dieldrin is one of the most persistent of the chlorinated hydrocarbons. Volatilization and possibly subsequent photolysis to photodieldrin are important transport and fate processes from surface water and probably from soil. Adsorption to sediments, especially organic materials, and bioaccumulation are also important in removing dieldrin from water. Biotransformation and biodegradation of dieldrin occur very slowly but may be the final fate processes in sediment.

Health Effects

Both aldrin and dieldrin are carcinogens, causing increases in a variety of tumors in rats at low but not at high doses and producing a higher incidence of liver tumors in mice. the reason for this reversed dose-response relationship is unclear. Neither appears to be mutagenic when tested in a number of systems. Aldrin and dieldrin are both toxic to the reproductive system and teratogenic. Reproductive effects include decreased fertility, increased fetal death, and effects on gestation; while teratogenic effects include cleft palate, webbed foot, and skeletal anomalies. Chronic effects attributed to aldrin and dieldrin include liver toxicity and central nervous system abnormalities. Both chemicals are acutely toxic; the oral LD_{50} is around 50 mg/kg, and the dermal LD_{50} is about 100 mg/kg.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life

Freshwater

Acute toxicity:	Aldrin: 3.0 ug/liter Dieldrin: 2.5 ug/liter
Chronic toxicity:	Aldrin: No available data Dieldrin: 0.0019 ug/liter

Saltwater

Acute toxicity: Aldrin: 1.3 ug/liter
Dieldrin: 0.71 ug/liter

Chronic toxicity: Aldrin: No available data
Dieldrin: 0.0019 ug/liter

Human Health

Estimates of the carcinogenic risks associated with lifetime exposure to various concentrations in water are:

Risk	Aldrin Concentration	Dieldrin Concentration
10^{-5}	0.74 ng/liter	0.71 ng/liter
10^{-6}	0.074 ng/liter	0.071 ng/liter
10^{-7}	0.0074 ng/liter	0.0071 ng/liter

CAG Unite Risk (U.S. EPA): Aldrin: 11.4 $(mg/kg/day)^{-1}$
Dieldrin: 30.4 $(mg/kg/day)^{-1}$

ACGIH Threshold Limit Value:* 0.25 mg/m^3 TWA
0.75 mg/m^3 STEL

OSHA Standard (air):* 250 ug/m^3 TWA

* Applies to both aldrin and dieldrin.

ARSENIC

Summary

Arsenic is a metal that is present in the environment as a constituent of organic and inorganic compounds; it also occurs in a number of valence states. Arsenic is generally rather mobile in the natural environment, with the degree of mobility dependent on its chemical form and the properties of the surrounding medium. Arsenic is a human carcinogen; it causes skin tumors when it is ingested and lung tumors when it is inhaled. Arsenic compounds are teratogenic and have adverse reproductive effects in animals. Chronic exposure to arsenic is associated with polyneuropathy and skin lesions. It is acutely toxic to some early life stages of aquatic organisms at levels as low as 40 ug/liter.

Background Information

Arsenic can be found in the environment in any of four valence states (-3, 0, +3 and +5) depending on the pH, Eh, and other factors. It can exist as either inorganic or organic compounds and often will change forms as it moves through the various media. The chemical and physical properties depend on the state of the metalloid. Only the properties of metallic arsenic have been listed; properties of other arsenic compounds are often quite different.

CAS Number: 7440-38-2

Chemical Formula: As

IUPAC Name: Arsenic

Chemical and Physical Properties

Atomic Weight: 74.91

Boiling Point: 613°C

Melting Point: 817°C

Specific Gravity: 5.72 at 20°C

Solubility in Water: Insoluble; some salts are soluble.

Transport and Fate

In the natural environment, arsenic has four different oxidation states, and chemical speciation is important in determining arsenic's distribution and mobility. Interconversions of the +3 and +5 states as well as organic complexation, are the most important. Arsenic is generally quite mobile in the environment. In the aquatic environment, volatilization is important when biological activity or highly reducing conditions is an important fate for the chemical. Arsenic is metabolized to organic arsenicals by a number of organisms; this increases arsenic's mobility in the environment. Because of its general mobility, arsenic tends to cycle through the environment. Its ultimate fate is probably the deep ocean, but it may pass through numerous stages before finally reaching the sea.

Health Effects

Arsenic has been implicated in the production of skin cancer in humans. There is also extensive evidence that inhalation of arsenic compounds causes lung cancer in workers. Arsenic compounds cause chromosome damage in animals, and humans exposed to arsenic compounds have been reported to have an elevated incidence of chromosome aberrations. Arsenic compounds have been reported to be teratogenic, fetotoxic, and embryotoxic in several animal species, and an increased incidence of multiple malformations among children born to women occupationally exposed to arsenic has been reported. Arsenic compounds also cause noncancerous, possibly precancerous, skin changes in exposed individuals. Several cases of progressive polyneuropathy involving motor and sensory nerves and particularly affecting the extremities and myelinated long-axon neurons have been reported in individuals occupationally exposed to inorganic arsenic. Polyneuropathies have also been reported after the ingestion of arsenic-contaminated foods.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life

Freshwater

Acute toxicity: 440 ug/liter
Chronic toxicity: No available data

Saltwater

Acute toxicity: 508 ug/liter
Chronic toxicity: No available data

Human Health

Estimates of the carcinogenic risks associated with lifetime exposure to various concentrations of arsenic in water are:

Risk	Concentration
10^{-5}	22 ng/liter
10^{-6}	2.2 ng/liter
10^{-7}	0.22 ng/liter

CAG Unit Risk (U.S. EPA): 15 $(mg/kg/day)^{-1}$

National Interim Primary Drinking Water Standard (U.S. EPA): 50 ug/liter

NIOSH Recommended Standard (air): 2 ug/m^3 TWA

OSHA Standard (air): 500 ug/m^3 TWA

ACGIH Threshold Limit Value: 200 ug/m^3 (soluble compounds, as As).

BENZENE

Summary

Benzene is an important industrial solvent and chemical intermediate. It is rather volatile, and atmospheric photooxidation is probably an important fate process. Benzene is a known human carcinogen, causing leukemia in exposed individuals. It also adversely affects the hematopoietic system. Benzene has been shown to be fetotoxic and to cause embryolethality in experimental animals. Exposure to high concentrations of benzene in the air causes central nervous system depression and cardiovascular effects, and dermal exposure may cause dermatitis.

CAS Number: 71-43-2

IUPAC Name: Benzene

Chemical Formula: C_6H_6

Chemical and Physical Properties

Molecular Weight: 78.12

Boiling Point: 80.1°C

Melting Point: 5.56°C

Specific Gravity: 0.879 at 20°C

Solubility in Water: 1,780 mg/liter at 25°C

Solubility in Organics: Miscible with ethanol, ether, acetic acid, acetone, chloroform, carbon disulfide, and carbon tetrachloride

Log Octanol/Water Partition Coefficient: 1.95-2.13

Vapor Pressure: 75 mm Hg at 20°C

Vapor Density: 2.77

Flash Point: -11.1°C

Transport and Fate

Volatilization appears to be the major transport process of benzene from surface waters to the ambient air, and atmospheric transport of benzene occurs readily (U.S. EPA 1979). Although direct oxidation of benzene in environmental waters is

unlikely, cloud chamber data indicate that it may be photooxidized rapidly in the atmosphere. Inasmuch as volatilization is likely to be the main transport process accounting for the removal of benzene from water, the atmospheric destruction of benzene is probably the most likely fate process. Values for benzene's log octanol/water partition coefficient indicate that adsorption onto organic material may be significant under conditions of constant exposure. Sorption processes are likely removal mechanisms in both surface water and groundwater. Although the bioaccumulation potential for benzene appears to be low, gradual biodegradation by a variety of microorganisms probably occurs. The rate of benzene biodegradation may be enhanced by the presence of other hydrocarbons.

Health Effects

Benzene is a recognized human carcinogen. Several epidemiological studies provide sufficient evidence of a causal relationship between benzene exposure and leukemia in humans. Benzene is a known inducer of aplastic anemia in humans, with a latent period of up to 10 years. It produces leukopenia and thrombocytopenia, which may progress to pancytopenia. Similar adverse effects on the blood-cell-producing system occur in animals exposed to benzene. In both humans and animals, benzene exposure is associated with chromosomal damage, although it is not mutagenic in microorganisms. Benzene was fetotoxic and caused embryolethality in experimental animals.

Exposure to very high concentrations of benzene [about 20,000 ppm (66,000 mg/m^3) in air] can be fatal within minutes. The prominent signs are central nervous system depression and convulsions, with death usually following as a consequence of cardiovascular collapse. Milder exposures can produce vertigo, drowsiness, headache, nausea, and eventually unconsciousness if exposure continues. Deaths from cardiac sensitization and cardiac arrhythmias have also been reported after exposure to unknown concentrations. Although most benzene hazards are associated with inhalation exposure, dermal absorption of liquid benzene may occur, and prolonged or repeated skin contact may produce blistering, erythema, and a dry, scaly dermatitis.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life

The available data are not adequate for establishing criteria. However, EPA did report the lowest concentrations of benzene known to cause toxic effects in aquatic organisms.

Freshwater

Acute toxicity: 5,300 ug/liter
Chronic toxicity: No available data

Saltwater

Acute toxicity: 5,100 ug/liter
Chronic toxicity: No available data

Human Health

Estimates of the carcinogenic risks associated with lifetime exposure to various concentrations of benzene in water are:

Risk	Concentration
10^{-5}	6.6 ug/liter
10^{-6}	0.66 ug/liter
10^{-7}	0.066 ug/liter

CAG Unit Risk (U.S. EPA): 2.0×10^{-2} $(mg/kg/day)^{-1}$

OSHA Standard (air): 30 mg/m^3 TWA
75 mg/m^3 Ceiling Level
150 mg/m^3 10-min Peak Level

ACGIH Threshold Limit Value: Suspected human carcinogen
30 mg/m^3 TWA
75 mg/m^3 STEL

CADMIUM

Summary

Cadmium is a metal that can be present in a variety of chemical forms in wastes or in the environment. Some forms are insoluble in water, but cadmium is relatively mobile in the aquatic environment. Cadmium is carcinogenic in animals exposed by inhalation and may also be in humans. It is uncertain whether it is carcinogenic in animals or humans exposed via ingestion. Cadmium is a known animal teratogen and reproductive toxin. It has chronic effects on the kidney, and background levels of human exposure are thought to provide only a relatively small margin of safety for these effects.

Background Information

Cadmium is a soft, bluish white metal that is obtained as a by-product from the treatment of the ores of copper, lead, and iron. Cadmium has a valence of +2 and has properties similar to those of zinc. Cadmium forms both organic and inorganic compounds. Cadmium sulfate is the most common salt.

CAS Number: 7440-43-9

Chemical Formula: Cd

IUPAC Name: Cadmium

Chemical and Physical Properties

Atomic Weight: 112.41

Boiling Point: 765°C

Melting Point: 321°C

Specific Gravity: 8.642

Solubility in Water: Salts are water soluble; metal is insoluble

Solubility in Organics: Variable, based on compound

Vapor Pressure: 1 mm Hg at 394°C

Transport and Fate

Cadmium is relatively mobile in the aquatic environment compared to other heavy metals. It is removed from aqueous media by complexing with organic materials and subsequently being adsorbed to the sediment. It appears that cadmium moves slowly through soil, but only limited information on soil transport is available. Cadmium uptake by plants is not a significant mechanism for depletion of soil accumulations but may be significant for human exposure.

Health Effects

There is suggestive evidence linking cadmium with cancer of the prostate in humans. In animal studies, exposure to cadmium by inhalation caused lung tumors in rats, and exposure by injection produced injection-site sarcomas and/or Leydig-cell tumors. An increased incidence of tumors has not been seen in animals exposed to cadmium orally, but four of the five available studies were inadequate by current standards.

The evidence from a large number of studies on the mutagenicity of cadmium is equivocal, and it has been hypothesized that cadmium is not directly mutagenic but impedes repair. Cadmium is a known animal teratogen and reproductive toxin. It has been shown to cause renal dysfunction in both humans and animals. Other toxic effects attributed to cadmium include immunosuppression (in animals), anemia (in humans), pulmonary disease (in humans), possible effects on the endocrine system, defects in sensory function, and bone damage. The oral LD_{50} in the rat was 225 mg/kg.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life (Proposed 1984)

Freshwater

Acute toxicity: $e^{\{1.30[\ln(\text{hardness})] - 3.92\}}$ ug/liter
Chronic toxicity: $e^{\{1.30[\ln(\text{hardness})] - 3.92\}}$ ug/liter

Saltwater

Acute toxicity: 38 ug/liter
Chronic toxicity: 12 ug/liter

Human Health

Criterion: 10 ug/liter

CAG Unit Risk for inhalation exposure (U.S. EPA): 6.1 $(mg/kg/day)^{-1}$

Interim Primary Drinking Water Standard (U.S. EPA): 10 ug/liter

NIOSH Recommended Standards: 40 ug/m^3 TWA
200 ug/m^3/15 min Ceiling Level

OSHA Standard (air): 200 ug/m^3 TWA
600 ug/m^3 Ceiling Level

ACGIH Threshold Limit Value: 50 ug/m^3 TWA

CARBON TETRACHLORIDE

Summary

Carbon tetrachloride is used as a industrial solvent and chemical intermediate. It is an animal carcinogen, causing liver tumors in mice, rats, and hamsters. Carbon tetrachloride also causes liver and kidney damage in animals and humans.

Chemical Formula: CCl_4

IUPAC Name: Tetrachloromethane

Important Synonyms and Trade Names: Tetrachoromethane, perchloromethane

Chemical and Physical Properties

Molecular Weight: 153.8

Boiling Point: 76.7°C

Melting Point: 22.9°C

Specific Gravity: 1.59 at 20°C (liquid)
5.3 vapor (gas) specific gravity

Solubility in Water: 800 mg/liter

Solubility in Organics: Miscible with alcohol, benzene, chloroform, ether, and carbon disulfide

Log Octanol/Water Partition Coefficient: 2.64

Vapor Pressure: 90 mm Hg at 20°C

Vapor Density: 5.32

Transport and Fate

Carbon tetrachloride has a high vapor pressure and therefore volatilizes rapidly into the atmosphere from surface water and probably from soil. It is relatively soluble in water and therefore would be expected to be transported in groundwater. Because of its high specific gravity, it may move independently from the groundwater as a nonaqueous phase liquid.

Health Effects

Carbon tetrachloride was carcinogenic in mice, rats, and hamsters; in all cases liver tumors were induced. In addition, mice also displayed a high incidence of tumors of the adrenal gland. Studies discussed by EPA (1980) on the mutagenic and teratogenic effects of carbon tetrachloride and its impact on reproduction are inconclusive. Carbon tetrachloride also causes both liver and kidney damage in animals and humans. One study in which guinea pigs were repeatedly exposed to carbon tetrachloride vapor for several months provided evidence of damage to the optic nerve and degeneration of the myelin sheath of the sciatic nerve.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life

The available data are not adequate for establishing criteria. However, EPA did report the lowest values known to cause toxicity in aquatic organisms.

Freshwater

Acute toxicity: 35,200 ug/liter
Chronic toxicity: No available data

Saltwater

Acute toxicity: 50,000 ug/liter
Chronic toxicity: No available data

Human Health

Estimates of the carcinogenic risks associated with lifetime exposure to carbon tetrachloride at various concentrations in water are:

Risk	Concentration
10^{-5}	4.0 ug/liter
10^{-6}	0.4 ug/liter
10^{-7}	0.04 ug/liter

CAG Unit Risk (U.S. EPA): 1.3×10^{-1} $(mg/kg/day)^{-1}$

OSHA Standard (air): 10 ppm TWA
25 ppm Ceiling Level

ACGIH Threshold Limit Value: 5 ppm Skin.

CHLOROBENZENE

Summary

Chlorobenzene is used as a solvent and as a raw material in chemical manufacturing. It is persistent in the environment and can be adsorbed to organic material in soil. Chlorobenzene may cause liver tumors in male mice. Animals exposed to chlorobenzene have exhibited liver and kidney damage. Chlorobenzene is not very toxic to aquatic organisms; none of the LC_{50} values are less than 10 mg/liter.

CAS Number: 108-90-7

Chemical Formula: C_6H_5Cl

IUPAC Name: Chlorobenzene

Important Synonyms and Trade Names: Monochlorobenzene, benzene chloride, phenyl chloride

Chemical and Physical Properties

Molecular Weight: 112.6

Boiling Point: 131°C

Melting Point: -46°C

Specific Gravity: 1.11 at 20°C (liquid)

Solubility in Water: 500 mg/liter

Solubility in Organics: soluble in alcohol, benzene, chloroform, ether, and carbon tetrachloride

Log Octanol/Water Partition Coefficient: 2.83

Vapor Pressure: 8.8 mm Hg at 20°C

Vapor Density: 3.88

Henry's Law Constant: 3.56×10^{-3} atm m^3/mole at 25°C

Flash Point: 28°C

Transport and Fate

Chlorobenzene is probably removed from surface water primarily by volatilization, although adsorption and bioaccumulation may also be factors. Monochlorobenzene would be expected to move slowly in soil because of its high octanol/water partition coefficient and consequent adsorption to soil organic material.

Health Effects

A study of the carcinogenicity of chlorobenzene was recently completed by the National Toxicology Program and preliminary results show that chlorobenzene caused neoplastic nodules in the liver of male rats but was not carcinogenic in female rats or in mice.

Occupational studies suggest that chronic exposure to monochlorobenzene vapor may cause blood dyscrasia, hyperlipidemia, and cardiac dysfunction in humans. Like many organic solvents, monochlorobenzene is a central nervous system depressant in overexposed humans, but no chronic neurotoxic effects have been reported. animals exposed to chlorobenzene have exhibited liver and kidney damage and atrophy of the seminiferous tubules in the testes. The oral LD_{50} value for rats was 2910 mg/kg.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life

The available data are not adequate for establishing criteria.

Human Health

Health criterion: 488 ug/liter
Organoleptic criterion: 20 ug/liter

OSHA Standard (air): 350 mg/m^3 TWA

ACGIH Threshold Limit Value: 350 mg/m^3 TWA - 75 ppm.

CHLOROFORM

Summary

Chloroform (trichloromethane) is often produced during the chlorination of drinking water and thus is a common drinking water contaminant. It is volatile in surface waters and is not likely to be persistent in the environment. Chloroform caused an increase in kidney epithelial tumors in rats and in hepatocellular carcinomas in mice. In addition, there is suggestive evidence from epidemiological studies that exposure to chloroform and other trihalomethanes is associated with an increased incidence of bladder tumors in humans. Other toxic effects of chloroform include central nervous system depression; eye, skin, and gastrointestinal irritation; and damage to the liver, heart, and kidney.

CAS Number: 67-66-3

Chemical Formula: $CHCl_3$

IUPAC Name: Trichloromethane

Chemical and Physical Properties

Molecular Weight: 119.38

Boiling Point: 61.7°C

Melting Point: -63.5°C

Specific Gravity: 1.4832 at 20°C (liquid)

Solubility in Water: 8,200 mg/liter at 20°C

Solubility in Organics: soluble in acetone; miscible with alcohol, ether, benzene, and ligroin

Log Octanol/Water Partition Coefficient: 1.97

Vapor Pressure: 150.5 mm Hg at 20°C

Vapor Density: 4.12

Transport and Fate

Volatilization into the atmosphere is the major transport process for removal of chloroform from aquatic systems. Once in the troposphere, chloroform is attacked by hydroxyl radicals with the subsequent formation of phosgene ($COCl_2$) and possibly chlorine oxide (ClO) radicals. Neither of these reaction products is likely to persist;

phosgene is readily hydrolyzed to hydrochloric acid and carbon dioxide. Reaction with hydroxy radicals is thought to be the primary environmental fate of chloroform. However, chloroform that remains in the troposphere may return to earth in precipitation or adsorbed on particulates, and a small amount may diffuse upward to the stratosphere where it photodissociates via interaction with ultraviolet light.

Photolysis, hydrolysis, and sorption do not appear to be significant environmental fate processes for chloroform. However, sorption processes may have some importance as a removal mechanism in groundwater and soil. The log octanol/water partition coefficient6 indicates that this compound may bioaccumulate under conditions of constant exposure. Studies with marine organisms provide evidence for only weak to moderate bioaccumulation. Although chloroform is somewhat lipophilic and tends to be found at higher concentrations in fatty tissues, there is no evidence for biomagnification in aquatic food chains.

Health Effects

Chronic administration of chloroform by gavage is reported to produce a dose-related increase in the incidence of kidney epithelial tumors in rats and a dose-related increase in the incidence of hepatocellular carcinomas in mice. Epidemiological studies suggest that higher concentrations of chloroform and other trihalomethanes in water supplies may be associated with an increased frequency of bladder cancer in humans. However, these results are not sufficient to establish causality. An increased incidence of fetal abnormalities was reported in offspring of pregnant rats exposed to chloroform by inhalation. Oral doses of chloroform that caused maternal toxicity produced relatively mild fetal toxicity in the form of reduced birth weights. There are limited data suggesting that chloroform has mutagenic activity in some test systems. However, negative results have been reported for bacterial mutagenesis assays.

Humans may be exposed to chloroform by inhalation, ingestion, or skin contact. Toxic effects include local irritation of the skin or eyes, central nervous system depression, gastrointestinal irritation, liver and kidney damage, cardiac arrhythmia, ventricular tachycardia, and bradycardia. Death from chloroform overdosing can occur and is attributed to ventricular fibrillation. Chloroform anesthesia can produce delayed death as a result of liver necrosis.

Exposure to chloroform by inhalation, intragastric administration, or intraperitoneal injection produces liver and kidney damage in laboratory animals. The oral LD_{50} and inhalation LC_{LO} values for the rat are 908 mg/kg and 39,000 mg/m^3 per 4 hours, respectively.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life

The available data are not adequate for establishing criteria.

Human Health

Estimates of the carcinogenic risks associated with lifetime exposure to various concentrations of chloroform in water are:

Risk	Concentration
10^{-5}	1.90 ug/liter
10^{-6}	0.19 ug/liter
10^{-7}	0.019 ug/liter

CAG Unit Risk (U.S. EPA): 8.1×10^{-2} $(mg/kg/day)^{-1}$

DDT

Summary

DDT is an organochlorine pesticide, which together with its metabolites, is very persistent in the environment. DDT, DDE, and DDD have been shown to be carcinogenic in mice. They primarily cause liver tumors, but they also increase the incidence of lung tumors and lymphomas. In addition, DDT is a reproductive toxin. Chronic exposure can damage the central nervous system and liver. DDT and other organochlorine pesticides are highly toxic to aquatic organisms and are responsible for the decreased reproductive success of many bird species.

Background Information

Technical DDT is a mixture containing 65-89% p, p'-DDT, 15-20% o,p'-DDT, up to 4% p,p'-DDD, and traces of other materials. Metabolites of DDT include p,p'-DDE and o,p'-DDD. The DDT isomers and metabolites are usually found together and generally have similar properties; therefore, they will be considered together. Where differences occur the specific isomer will be identified. DDT will be used to refer to the combination of technical material and metabolites. Specific DDT isomers will be identified as such.

CAS Number:
- p,p'-DDT: 50-29-3
- o,p'-DDT: 789-02-6
- p,p'-DDD: 72-54-8
- o,p'-DDD: 53-19-0
- p,p'-DDE: 72-55-9

Chemical Formula:
- p,p'- and o,p'-DDT: $C_{14}H_9Cl_5$
- p,p'- and o,p'-DDD: $C_{13}H_{10}Cl_4$
- p,p'- and o,p'-DDE: $C_{14}H_8Cl_4$

IUPAC Name:
- p,p'-DDT: 1,1,1-Trichloro-2,2-bis(4-chlorophenyl)ethane
- o,p'-DDT: 1,1,1-Trichloro-2-(2-chlorophenyl)-2-(4-chlorophenyl)ethane
- p,p'-DDD: 1,1-Dichloro-2,2-bis(4-chlorophenyl)-ethane
- o,p'-DDE: 1,1-Dichloro-2,2-bis(4-chlorophenyl)-ethene

Important Synonyms and Trade Names:
- DDT: Dichlorodiphenyltrichloroethane, dicophane, chlorophenothane, Gesarol, Neocid
- p,p'-DDD: TDE, Rothane

Chemical and Physical Properties

Molecular Weight: o,p- and p,p'-DDT: 354.5
DDD: 320
DDE: 318

Boiling Point: DDT: 260°C

Melting Point: DDT: 109°C
DDD: 112°C
DDE: 90°C

Solubility in Water: p,p'-DDT: 5.5 ug/liter
o,p'-DDT: 26 ug/liter
p,p'-DDD: 20 ug/liter
DDE: 14 ug/liter

Solubility in Organics: DDT: soluble in acetone, benzene, cyclohexanane, morpholine, pyridine, and dioxane

Log Octanol/Water Partition Coefficient:

DDT: 4,98
p,p'-DDT: 3.98
p,p'-DDD: 5.99
o,p'-DDD: 6.08
DDE: 5.69

Vapor Pressure:

p,p'-DDT: 1.9×10^{-7} mm Hg at 25°C
p,p'-DDT: 7.3×10^{-7} mm Hg at 30°C
o,p'-DDT: 5.5×10^{-6} mm Hg at 30°C
p,p'-DDD: 1.0×10^{-6} mm Hg at 30°C
o,p'-DDD: 1.9×10^{-6} mm Hg at 30°C
-DDE: 6.5×10^{-6} mm Hg at 20°C

Transport and Fate

DDT and it metabolites are very persistent in the environment. Volatilization is probably the most important transport process from soil and water for p,p'-DDT and o,p'-DDT, as evidenced by the ubiquitous nature of DDT in the environment.

Sorption and bioaccumulation are the most important transport processes for the DDT isomers. Although it only occurs slowly, the ultimate fate process for p,p'-DDT, o,p'-DDT, and DDD is biotransformation to form bis (2-chlorophenyl)methanone (DDCO). Indirect photolysis may also be important for p,p'-DDT and o,p'-DDT in aquatic environments. For DDE, direct photolysis is the most important ultimate fate process in the environment although biotransformation may also be important.

Health Effects

DDT, DDE, and DDD have been shown to be carcinogenic to mice, primarily causing liver tumors, but also causing lung tumors and lymphomas. DDT does not appear to be mutagenic, but it has caused chromosomal damage. There is no evidence that DDT is a teratogen; but it is a reproductive toxin, causing reduced fertility, reduced growth of offspring, and fetal mortality.

Chronic exposure to DDT causes a number of adverse effects, especially to the liver and central nervous system (CNS). DDT induces various microsomal enzymes and therefore probably affects the metabolism of steroid hormones and exogenous chemicals. Other effects on the liver include hypertrophy of the parenchymal cells and increased fat deposition. In the CNS, exposure to DDT cause behavioral effects such as decreased aggression and decreased conditional reflexes. Acute exposure to large doses or chronic exposure to lower doses causes seizures. The oral LD_{50} is between 113 and 450 mg/kg for the rat and is generally higher for other animals.

DDT, DDD, and DDE are bioconcentrated and stored in the adipose tissues of most animals.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life

DDT: Freshwater

Acute toxicity: 1.1 ug/liter
Chronic toxicity: 0.001 ug/liter

Saltwater

Acute toxicity: 0.13 ug/liter
Chronic toxicity: 0.001 ug/liter

DDD and DDE:

The available data are not adequate for establishing criteria. However, EPA did report the lowest values known to be toxic in aquatic organisms.

Freshwater

Acute toxicity:	DDD: 0.6 ug/liter
	DDE: 1050 ug/liter
Chronic toxicity:	DDD & DDE: No available data

Saltwater

Acute toxicity:	DDD: 3.6 ug/liter
	DDE: 14 ug/liter
Chronic toxicity:	DDD & DDE: No available data

Human Health

Estimates of the carcinogenic risks associated with lifetime exposure to various concentrations of DDT in water are:

Risk	Concentration
10^{-5}	0.24 ng/liter
10^{-6}	0.024 ng/liter
10^{-7}	0.0024 ng/liter

CAG Unit Risk (U.S. EPA): 0.34 $(mg/kg/day)^{-1}$

OSHA Standard (air): 1 mg/m^3 TWA

ACGIH Threshold Limit Value: 1 mg/m^3 TWA

DIBROMOCHLOROPROPANE

Summary

Dibromochloropropane (DBCP) was formerly used as a soil fumigant and nematocide. It has been found to be carcinogenic in mice and rats. It causes mammary tumors (in female rats only) and forestomach tumors when administered orally, and nasal, tongue, and lung tumors when given by inhalation. Men occupationally exposed to DBCP had abnormally low sperm counts. Animals studies have shown that dibromochloropropane has adverse effects on the liver, kidneys, and blood cells.

CAS Number: 96-12-8

Chemical Formula: $C_3H_5Br_2Cl$

IUPAC Name: 1,2-Dibromo-3-chloropropane

Important Synonyms and Trade Names: DBCP, Fumazone, Nemagon

Chemical and Physical Properties

Molecular Weight: 236.36

Boiling Point: 196°C

Melting Point: 6°C

Specific Gravity: 2.093 at 14°C

Solubility in Water: Slightly soluble (probably 5-10 g/liter)

Solubility in Organics: Miscible with oils, dichloropropane, and isopropyl alcohol

Vapor Pressure: 0.8 mm Hg at 21°C

Transport and Fate

There was no information available on the transport and fate of 1,2-dribromo-3-chloropropane (DBCP) at the time of this review. However, there is some information on the transport and fate of structurally similar compounds that may be relevant to the environmental fate of DBCP.

1,2,3-Trichloropropane was found to have a half-life of 51 minutes in stirred water, suggesting volatilization of DBCP from water could be significant. However, DBCP is considerably heavier than 1,2,3-trichloropropane and thus somewhat less likely to volatilize. The log octanol/water partition coefficient, 2.28 of 1,2-dichloropropane4 suggests that it will readily adsorb to organic components of soils and sediments and, therefore, be transported in dust and suspended solids. The tendency of brominated aliphatics to have higher log octanol/water portion coefficients than chlorinated aliphatics suggest DBCP will adsorb to a greater degree than 1,2-dichloropropane. Because of its water solubility, density, and low vapor pressure, DBCP is a likely groundwater contaminant. Its high density suggests that it would settle to the bottom of a contaminant plume and ultimately to the bottom of the aquifer.

Based on information of one and two carbon aliphatics, DBCP may be oxidized in the troposphere by hydroxyl radicals and hydrolyzed in an aqueous environment. Biodegradation of 1,2-dichloropropane does occur by soil microorganisms. However, the amount and speed of biodegradation and chemical degradation of DBCP is unknown.

Health Effects

DBCP has been found to be carcinogenic in two animal bioassays and mutagenic in the Ames assay system. In a gavage study, DBCP was found to produce significantly increased incidences of squamous-cell carcinomas of the forestomach of mice and rats and of mammary adenocarcinomas in female rats. In an inhalation study, rats had increased incidences of nasal cavity tumors and tumors of the tongue, while mice had increased incidences of nasal cavity tumors and lung tumors.

Men occupationally exposed to DBCP during its manufacture were found to have abnormally low sperm counts. Male rats exposed to DBCP during subchronic toxicity studies were also found to have abnormally low sperm cells as well as degenerative changes in the seminiferous tubules, decreased weight of the testes, and an increased proportion of abnormal sperm cells. Liver and kidney effects have also been noted in animal studies. Effects range from dilatation of the sinusoids and centrilobular congestion to cirrhosis and necrosis in the liver. Cloudy swelling of the epithelium of the proximal convoluted tubules and increased amounts of interstitial tissue have been found in the kidneys. Effects on blood cells were also noted in several studies. These effects include severe leukopenias and anemias in exposed monkeys and decreased activity of phagocytic cells in exposed rats.

Regulations and Standards

NIOSH Recommended Standard: 10 ppb (0.1 mg/m^3)

OSHA Standard (air): 1 ppb (9.6 ug/m^3) TWA

1,1-DICHLOROETHANE

Summary

1,1-Dichloroethane is quite volatile and probably is not very persistent in aquatic environments. Inhalation exposure to high doses causes central nervous system depression in humans and may cause hepatotoxicity. In animals, high doses cause liver and kidney damage and retard fetal development.

CAS Number: 75-34-3

Chemical Formula: CH_3CHCl_2

IUPAC Name: 1,1-Dichloroethane

Important Synonyms and Trade names: Ethylidene chloride, ethylidene dichloride

Chemical and Physical Properties

Molecular Weight: 98.96

Boiling Point: 57.3°C

Melting Point: -97.0°C

Specific Gravity: 1.1776 at 20°C

Solubility in Water: 5 g/liter

Solubility in Organics: Miscible in alcohol

Log Octanol/Water Partition Coefficient: 1.79

Vapor Pressure: 180 mm Hg at 20°C

Transport and Fate

1,1-Dichloroethane disperses from surface water primarily by volatilization into the troposphere, where it is subsequently broken down by hydroxylation. No studies on adsorption were found in the literature reviewed, but because of its water solubility and relatively low log octanol/water partition coefficient, 1,1-dichloroethane potentially could move through soil and enter the groundwater.

Health Effects

Limited toxicological testing of 1,1-dichloroethane has been conducted, although the literature indicates that 1,1-dichloroethane is one of the least toxic of the chlorinated ethanes. An NCI bioassay on 1,1-dichloroethane was limited by poor survival of test animals, but some marginal tumorigenic effects were seen. Inhalation exposure to high doses of 1,1-dichloroethane (over 16,000 mg/m^3) caused retarded fetal development in rats. 1,1-Dichloroethane was not found to be mutagenic using the Ames assay. 1,1-Dichloroethane causes central nervous system depression when inhaled at high concentrations, and evidence suggests that the compound is hepatotoxic in humans. Kidney and liver damage was seen in animals exposed to high levels of 1,1-dichloroethane. The oral LD_{50} value in the rat is 725 mg/kg.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

The available data were inadequate for establishing criteria.

OSHA Standard (air): 400 mg/m^3 TWA

ACGIH Threshold Limit Value: 810 mg/m^3 TWA - 200 ppm

1,2-DICHLOROETHANE

Summary

1,2-Dichloroethane (ethylene dichloride) is a volatile organic solvent, and volatilization and percolation into groundwater may be significant routes of transport. It has a low solubility in water and may be a component in nonaqueous-phase liquids. 1,2-Dichloroethane is carcinogenic in animals and mutagenic in bacterial test systems; it is a suspected human carcinogen.

CAS Number: 107-06-02

Chemical Formula: CH_2ClCH_2Cl

IUPAC Name: 1,2-Dichloroethane

Important Synonyms and Trade Names: Ethylene dichloride, glycol dichloride.

Chemical and Physical Properties

Molecular Weight: 98.96

Boiling Point: 83-84°C

Melting Point: -35.4°C

Specific Gravity: 1.253 at 20°C

Solubility in Water: 8 g/liter

Solubility in Organics: Miscible with alcohol, chloroform, and ether

Log Octanol/Water Partition Coefficient: 1.48

Vapor Pressure: 61 mm Hg at 20°C

Flash Point: 15°C (closed cup)

Transport and Fate

The primary method of dispersion from surface water for 1,2-dichloroethane is volatilization. In the atmosphere, 1,2-dichloroethane is rapidly broken down by hydroxylation, although some may be absorbed by atmospheric water and return to the earth by precipitation. No studies on the adsorption of 1,2-dichloroethane onto soil were reported in the literature examined. However, 1,2-dichloroethane has a low octanol/water partition coefficient, is slightly soluble in water, and therefore leaching through the soil into the groundwater is an expected route of dispersal.

Health Effects

1,2-Dichloroethane is carcinogenic in rats and mice, producing a variety of tumors. When administered by gavage, it produced carcinomas of the forestomach and hemangiosarcomas of the circulatory system in male rats; adenocarcinomas of the mammary gland in female rats; lung adenomas in male mice; and lung adenomas, mammary adenocarcinomas, and endometrial tumors in female mice. It is mutagenic when tested using bacterial test systems. Human exposure by inhalation to 1,2-dichloroethane has been shown to cause headache, dizziness, nausea, and liver and kidney dysfunction. Dermatitis may be produced by skin contact. In severe cases, leukocytosis (an excess of white blood cells) may be diagnosed; and internal hemorrhaging and pulmonary edema leading to death may occur. Similar effects are produced in experimental animals.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life

The available data are not adequate for establishing criteria. However, EPA did report the lowest values known to be toxic in aquatic organisms.

Freshwater

Acute toxicity: 118 mg/liter
Chronic toxicity: 20 mg/liter

Saltwater

Acute toxicity: 113 mg/liter
Chronic toxicity: No available data

Human Health

Estimates of the carcinogenic risks associated with lifetime exposure to various concentrations of 1,2-dichloroethane in water are:

Risk	Concentration
10^{-5}	9.4 ug/liter
10^{-6}	0.94 ug/liter
10^{-7}	0.094 ug/liter

CAG Unit Risk (U.S. EPA): 9.1×10^{-2} $(mg/kg/day)^{-1}$

OSHA Standard (air): 200 mg/m^3 TWA
400 mg/m^3 Ceiling Level
800 mg/m^3 for 5 min every 3 hr, Peak Concentration

ACGIH Threshold Limit Value: 40 mg/m^3 TWA
10 ppm TWA

1,1-DICHLOROETHYLENE

Summary

1,1-Dichloroethylene (VDC, vinylidene chloride) caused kidney tumors (in males only) and leukemia in one study of mice exposed by inhalation, but the results of other studies were equivocal or negative. 1,1-Dichloroethylene is mutagenic, and it caused adverse reproductive effects when administered to rats and rabbits by inhalation. Chronic exposure causes liver damage, and acute exposure to high doses produces nervous system damage.

CAS Number: 75-35-4

Chemical Formula: CH_2CCl_2

IUPAC Name: 1,1-Dichloroethene

Important Synonyms and Trade Names: Vinylidene chloride, VDC, 1,1-dichloroethene, 1,1-DCE

Chemical and Physical Properties

Atomic Weight: 96.94

Boiling Point: 37°C

Melting Point: -122.1°C

Specific Gravity: 1.218 at 20°C

Solubility in Water: 400 mg/liter at 20°C

Solubility in Organics: Sparingly soluble in alcohol, ether, acetone, benzene, and chloroform

Log Octanol/Water Partition Coefficient: 1.48

Vapor Pressure: 500 mm Hg at 20°C

Vapor Density: 3.25

Transport and Fate

Volatilization appears to be the primary transport process for 1,1-dichloroethylene (VDC), and its subsequent photooxidation in the atmosphere by reaction with hydroxyl radicals is apparently the predominant fate process. Information on other transport and fate mechanisms was generally lacking for 1,1-dichloroethylene. However, by inference from related compounds, hydrolysis, sorption, bioaccumulation, biotransformation, and biodegradation probably all occur but at rates too slow to be of much significance.

Health Effects

1,1-Dichloroethylene caused kidney tumors in males and leukemia in males and females in one study of mice exposed by inhalation, gave equivocal results in other inhalation studies, and gave negative results in rats and mice following oral exposure and in hamsters following inhalation exposure. VDC was mutagenic in several bacterial assays. 1,1-Dichloroethylene did not appear to be teratogenic but did cause embryotoxicity and fetotoxicity when administered to rats and rabbits by inhalation. Chronic exposure to oral doses of VDC as low as 5 mg/kg/day caused liver changes in rats. Acute exposure to high doses causes central nervous system depression, but neurotoxicity has not been associated with low-level chronic exposure. The oral LD_{50} value for the rat is 1,500 mg/kg, and for the mouse it is 200 mg/kg.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life

The available data are inadequate for establishing criteria. However, EPA did report the lowest values known to cause toxicity in aquatic organisms.

Freshwater

Acute toxicity: 11,600 ug/liter
Chronic toxicity: No available data

Saltwater

Acute toxicity: 224,000 ug/liter
Chronic toxicity: No available data

Human Health

Estimates of the carcinogenic risks associated with lifetime exposure to various concentrations of 1,2-dichloroethane in water are:

Risk	Concentration
10^{-5}	0.33 ug/liter
10^{-6}	0.033 ug/liter
10^{-7}	0.0033 ug/liter

CAG Unit Risk (U.S. EPA): 1.16 $(mg/kg/day)^{-1}$

ACGIH Threshold Limit Value: 5 ppm TWA
20 mg/m^3 TWA
485 mg/m^3 STEL

1,2-TRANS-DICHLOROETHYLENE

Summary

Chronic inhalation exposure to 1,2-trans-dichloroethylene (1,2-trans-DCE) causes liver degeneration, and acute exposure to high levels has adverse effects on the central nervous system.

CAS Number: 540-59-0

Chemical Formula: $C_2H_2Cl_2$

IUPAC Name: 1,2-trans-Dichloroethene

Important Synonyms and Trade Names: trans-Acetylene dichloride, dioform

Chemical and Physical Properties

Molecular Weight: 96.94

Boiling Point: 47.5°C

Melting Point: -50°C

Specific Gravity: 1.2565 at 20°C

Solubility in Water: 600 mg/liter

Solubility in Organics: Miscible with alcohol, ether, and acetone; very soluble in benzene and chloroform

Log Octanol/Water Partition Coefficient: 1.48 (calculated)

Vapor Pressure: 200 mm Hg at 14°C

Flash Point: 3°C (undefined isomers)

Transport and Fate

Due to the relatively high vapor pressure of 1,2-trans-dichloroethylene (1,2-trans-DCE), volatilization from aquatic systems to the atmosphere is quite rapid and appears to be the primary transport process. Aerial transport of this compound can occur and is partly responsible for its relatively wide environmental distribution. Although little applicable information is available, adsorption is probably an insignificant environmental fate process for 1,2-trans-DCE. The relatively low log octanol/water partition coefficient of 1,2-trans-DCE suggests that bioaccumulation

also is a relatively insignificant process. Although no information pertaining specifically to biodegradation of 1,2-trans-DCE is available, results with similar compounds suggest that this process probably occurs but at a very slow rate.

Photooxidation in the troposphere appears to be the dominant environmental fate of 1,2-trans-DCE. Once in the troposphere, the compound is attacked at the double bond by hydroxyl radicals, resulting in the formation of formic acid, hydrochloric acid, carbon monoxide, and formaldehyde. The half-life of 1,2-trans-DCE in the troposphere is estimated to be less than one day. Given the properties of similar compounds, photolysis of 1,2-trans-DCE in aquatic systems and photodissociation in the terrestrial environment are probably insignificant.

Health Effects

Very little information concerning exposure only to 1,2-trans-DCE is available. There are no reports of carcinogenic or teratogenic activity by 1,2-trans-DCE in animals or humans. It is reportedly nonmutagenic in a variety of test systems. Like other members of the chlorinated ethylene series, 1,2-trans-DCE has anesthetic properties. Exposure to high vapor concentrations has been found to cause nausea, vomiting, weakness, tremor, and cramps in humans. Repeated exposure via inhalation of 800 mg/m^3 (8 hours/day, 5 days/week, for 16 weeks) was reported to produce fatty degeneration of the liver in rats. The intraperitoneal injection LD_{50} value for the rat is 7,536 mg/kg.

Although nephrotoxic and cardiac sensitizing effects are associated with exposure to 1,1-dichloroethylene, the 1,2-DCE isomers have not been investigated with respect to this type of effects. 1,2-trans-Dichloroethylene can inhibit aminopyrine demethylation in rat liver microsomes in vitro, and it may thus interact with the hepatic drug-metabolizing monooxygenase system.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

The available data are not adequate for establishing criteria.

OSHA Standard: 790 mg/m^3 TWA

ACGIH Threshold Limit Value: 790 mg/m^3 TWA
1,000 mg/m^3 STEL.

ENDRIN

Summary

Endrin is a cyclodiene insecticide that is an isomer of dieldrin. It is probably retained in soils and sediments and is persistent in the environment. It is strongly bioaccumulated by aquatic organisms. Endrin is highly toxic to mammals, aquatic organisms, and terrestrial wildlife4 after acute exposure. It has not been shown to be carcinogenic or mutagenic, but it is a potent teratogen and reproductive toxin.

CAS Number: 72-20-8

Chemical Formula: $C_{12}H_8Cl_6O$

IUPAC Name: 1,2,3,4,10,10-Hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a octahydro-endo-1,4:5,8-dimethanonaphthalene

Important Synonyms and Trade Names: Endrex, hexadrin, mendrin

Chemical and Physical Properties

Molecular Weight: 380.9

Melting Point: Decomposes at 235°C

Specific Gravity: 1.65 at 25°C

Solubility in Water: 250 ug/liter at 25°C

Solubility in Organics: Soluble in acetone, benzene, carbon tetrachloride, hexane, and xylene

Log Octanol/Water Partition Coefficient: 5.6

Vapor Pressure: 2.7×10^{-7} mm Hg at 25°C

Transport and Fate

Endrin is quite persistent in the environment. Volatilization from soil surfaces and probably from surface water is an important transport process. Subsequent photolysis to delta-keto endrin and endrin aldehyde are apparently important fate processes. No information on the ability of endrin to adsorb to soils and sediments was found in the literature reviewed, but the physical properties of the chemical suggest that sorption would be an important fate process. Endrin is readily bioconcentrated by aquatic organisms, with concentration factors of 10^3 to 10^4. Biotransformation and biodegradation may also be important fate processes for endrin.

Health Effects

Endrin has not been shown to be carcinogenic or mutagenic. However, it is a potent reproductive toxin and teratogen in experimental animals. Reproductive effects included fetal mortality and growth retardation, while teratogenic effects included cleft palate, open eye, clubbed foot, meningoencephales, and fused ribs. Chronic exposure to low levels of endrin primarily results in nervous system damage but also has adverse effects on the heart, lungs, liver, and kidneys. The acute toxicity of endrin is due to its effects on the central nervous system. The acute oral and dermal LD_{50} values for endrin to the rat were both approximately 15 mg/kg.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life

Freshwater

Acute toxicity: 0.18 ug/liter
Chronic toxicity: 0.0023 ug/liter

Saltwater

Acute toxicity: 0.037 ug/liter
Chronic toxicity: 0.0023 ug/liter

Human Health

Criterion: 1.0 ug/liter

Primary Drinking Water Standard: 1.0 ug/liter

OSHA Standard: 100 ug/m^3 TWA

ETHYLBENZENE

Summary

There is some evidence suggesting that ethylbenzene causes adverse reproductive effects in animals. Oral and inhalation exposure caused minor liver and kidney changes in rats. Ethylbenzene is a skin and eye irritant.

CAS Number: 100-41-4

Chemical Formula: $C_6H_5C_2H_5$

IUPAC Name: Ethylbenzene

Important Synonyms and Trade Names: Phenylethane, EB, ethylbenzol

Chemical and Physical Properties

Molecular Weight: 106.2

Boiling Point: 136.2°C

Melting Point: -95°C

Specific Gravity: 0.867 at 20°C (liquid)

Solubility in Water: 161 mg/liter at 25°C

Solubility in Organics: Freely soluble in organic solvents

Log Octanol/Water Partition Coefficient: 3.15

Vapor Pressure: 7 mm Hg at 20°C

Vapor Density: 3.66

Henry's Law constant: 6.44 atm. m^3/mole

Flash Point: 17.2°C

Transport and Fate

Only limited data are available on the transport and fate of ethylbenzene. Volatilization is probably the major route of elimination from surface water. Subsequent atmospheric reactions, especially photooxidation, are responsible for its fate. However, its high log octanol/water partition coefficient suggests that a

significant amount of ethylbenzene may be adsorbed by organic material in the sediment. Some soil bacteria are capable of using ethylbenzene as a source of carbon. However, the relative importance of this potential route of ethylbenzene elimination has not been determined.

Health Effects

Ethylbenzene has been selected by the National Toxicology Program to be tested for possible carcinogenicity, although negative results were obtained in mutagenicity assays in Salmonella typhimurium and Saccharomyces cerevisiae. There is recent animal evidence that ethylbenzene causes adverse reproductive effects. Ethylbenzene is a skin irritant, and its vapor is irritating to the eyes at a concentration of 200 ppm (870 mg/m^3) and above. When experimental animals were exposed to ethylbenzene by inhalation, 7 hours/day for 6 months, adverse effects were produced at concentrations of 600 ppm (2,610 mg/m^3) and above, but not at 400 ppm (1,740 mg/m^3). At 600 ppm rats and guinea pigs showed slight changes in liver and kidney weights, monkeys had slight changes in liver weight, and monkeys and rabbits experienced histopathologic changes in the testes. Similar effects on the liver and kidney were observed in rats fed ethylbenzene at 408 and 680 mg/kg/day for 6 months.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life

The available data are not adequate for establishing criteria. However, EPA did report the lowest values known to have toxic effects in aquatic organisms.

Freshwater

Acute toxicity: 32,000 ug/liter
Chronic toxicity: No available data

Saltwater

Acute toxicity: 430 ug/liter
Chronic toxicity: No available data

Human Health

Criterion: 1.4 mg/liter

OSHA Standard (skin): 435 mg/m^3 TWA

ACGIH Threshold Limit Values: 435 mg/m^3 TWA
100 ppm TWA
545 mg/m^3 STEL
125 ppm STEL

LEAD

Summary

Lead is a heavy metal that exists in one of three oxidation states, 0, +2, and +4. There is suggestive evidence that some lead salts are carcinogenic, inducing kidney tumors in mice and rats. Lead is also a reproductive hazard, and it can adversely affect the brain and central nervous system by causing encephalopathy and peripheral neuropathy. Chronic exposure to low levels of lead can cause subtle learning disabilities in children. Exposure to lead can also cause kidney damage and anemia, and it may have adverse effects on the immune system.

CAS Number: 7439-92-1

Chemical Formula: Pb

IUPAC Name: Lead

Chemical and Physical Properties

Atomic Weight: 207.19

Boiling Point: 1,740°C

Melting Point: 327.502°C

Specific Gravity: 11.35 at 20°C

Solubility in Water: Insoluble; some organic compounds are soluble

Solubility in Organics: Soluble in HNO_3 and hot, concentrated H_2SO_4

Transport and Fate

Some industrially produced lead compounds are readily soluble in water. However, metallic lead and the common lead minerals are insoluble in water. Natural compounds of lead are not usually mobile in normal surface or groundwater because the lead leached from ores is adsorbed by ferric hydroxide or combines with carbonate or sulfate ions to form insoluble compounds.

Movement of lead and its inorganic and organolead compounds as particulates in the atmosphere is a major environmental transport process. Lead carried in the atmosphere can be removed by either wet or dry deposition. Although little evidence is available concerning the photolysis of lead compounds in natural waters, photolysis

in the atmosphere occurs readily. These atmospheric processes are important in determining the form of lead entering aquatic and terrestrial systems.

The transport of lead in the aquatic environment is influenced by the speciation of the ion. Lead exists mainly as the divalent cation in most unpolluted waters and becomes adsorbed into particulate phases. However, in polluted waters organic complexation is most important. Volatilization of lead compounds probably is not important in most aquatic environments.

Sorption processes appear to exert a dominant effect on the distribution of lead in the environment. Adsorption to inorganic solids, organic materials, and hydrous iron and manganese oxides usually controls the mobility of lead and results in a strong partitioning of lead to the bed sediments in aquatic systems. The sorption mechanism most important in a particular system varies with geological setting, pH, Eh, availability of ligands, dissolved and particulate ion concentrations, salinity, and chemical composition. The equilibrium solubility of lead with carbonate, sulfate, and sulfide is low. Over most of the normal pH range, lead carbonate, and lead sulfate control solubility of lead in aerobic conditions, and lead sulfide and the metal control solubility in anaerobic conditions. Lead is strongly complexed to organic materials present in aquatic systems and soil. Lead in soil is not easily taken up by plants, and therefore its availability to terrestrial organisms is somewhat limited.

Bioaccumulation of lead has been demonstrated for a variety of organisms, and bioconcentration factors are within the range of 100-1,000. Microcosm studies indicate that lead is not biomagnified through the food chain. Biomethylation of lead by microorganisms can remobilize lead to the environment. The ultimate sink of lead is probably the deep oceans.

Health Effects

There is evidence that several lead salts are carcinogenic in mice or rats, causing tumors of the kidneys after either oral or parenteral administration. Data concerning the carcinogenicity of lead in humans are inconclusive. The available data are not sufficient to evaluate the carcinogenicity of organic lead compounds or metallic lead. There is equivocal evidence that exposure to lead causes genotoxicity in humans and animals. The available evidence indicates that lead presents a hazard to reproduction and exerts a toxic effect on conception, pregnancy, and the fetus in humans and experimental animals.

Many lead compounds are sufficiently soluble in body fluids to be toxic. Exposure of humans or experimental animals to lead can result in toxic effects in the brain and central nervous system, the peripheral nervous system, the kidneys, and the hematopoietic system. Chronic exposure to inorganic lead by ingestion or inhalation can cause lead encephalopathy, and severe cases can result in permanent brain damage. Lead poisoning may cause peripheral neuropathy in adults and children, and permanent learning disabilities that are clinically undetectable in children may be caused by exposure to relatively low levels. Short-term exposure to lead can cause reversible kidney damage, but prolonged exposure at high concentrations may result in progressive kidney damage and possibly kidney failure. Anemia, due to inhibition of hemoglobin synthesis and a reduction in the life span of circulating red blood

cells, is an early manifestation of lead poisoning. Several studies with experimental animals suggest that lead may interfere with various aspects of the immune response.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life (Proposed Criteria)

The concentrations below are for active lead, which is defined as the lead that passes through a 0.45-um membrane filter after the sample is acidified to pH 4 with nitric acid.

Freshwater

Acute toxicity: $e^{\{1.34[\ln(\text{hardness})] - 2.014\}}$ ug/liter

Chronic toxicity: $e^{\{1.34[\ln(\text{hardness})] - 5.245\}}$ ug/liter

Saltwater

Acute toxicity: 220 ug/liter
Chronic toxicity: 8.6 ug/liter

Human Health

Criterion: 50 ug/liter

Primary Drinking Water Standard: 50 ug/liter

NIOSH Recommended Standard: 0.10 mg/m^3 TWA (inorganic lead)

OSHA Standard: 50 ug/m^3 TWA

ACGIH Threshold Limit Values:

0.15 mg/m^3 TWA (inorganic dusts and fumes)
0.45 mg/m^3 STEL (inorganic dusts and fumes)

MERCURY

Summary

Both organic and inorganic forms of mercury are reported to be teratogenic and embryotoxic in experimental animals. In humans, prenatal exposure to methylmercury has been associated with brain damage. Other major target organs for organic mercury compounds in humans are the central and peripheral nervous system and the kidney. In animals, toxic effects also occur in the liver, heart, gonads, pancreas, and gastrointestinal tract. Inorganic mercury is generally less acutely toxic than organic mercury compounds, but it does affect the central nervous system adversely.

Background Information

Several forms of mercury, including insoluble elemental mercury, inorganic species, and organic species, can exist in the environment. In general, the mercurous (+1) salts are such less soluble than the more commonly found mercuric (+2) slats. Mercury also forms many stable organic complexes that are generally much more soluble in organic liquids than in water. The nature and solubility of the chemical species that occur in an environmental system depend on the redox potential and the pH of the environment.

CAS Number: 7439-97-6

Chemical Formula: Hg

IUPAC Name: Mercury

Chemical and Physical Properties

Atomic Weight: 200.59

Boiling Point: 356.58°C

Melting Point: -38.87°C

Specific Gravity: 13.5939 at 20°C

Solubility in Water: 81.3 ug/liter at 30°C; some salts and organic compounds are soluble.

Solubility in Organics: Depends on chemical species

Vapor Pressure: 0.0012 mm Hg at 20°C

Transport and Fate

Mercury and certain of its compounds, including several inorganic species and dimethyl mercury, can volatilize to the atmosphere from aquatic and terrestrial sources. Volatilization is reduced by conversion of metallic mercury to complexed species and by deposition of HgS in reducing sediments, but even so atmospheric transport is the major environmental distribution pathway for mercury. Precipitation is the primary mechanism for removal of mercury from the atmosphere. Photolysis is important in the breakdown of airborne mercurials and may be important in some aquatic systems. Adsorption onto suspended and bed sediments is probably the most important process determinating the fate of mercury in the aquatic environment. Sorption is strongest into organic materials. Mercury in soils is generally complexed to organic compounds.

Virtually any mercury compound can be remobilized in aquatic systems by microbial conversion to methyl and dimethyl forms. Conditions reported to enhance biomethylation include large amounts of available mercury, large numbers of bacteria, the absence of strong complexing agents, near neutral pH, high temperatures, and moderately aerobic environments. Mercury is strongly bioaccumulated by numerous mechanisms. Methylmercury is the most readily accumulated and retained form of mercury in aquatic biota, and once it enters a biological system it is very difficult to eliminate.

Health Effects

When administered by intraperitoneal injection, metallic mercury produces implantation site sarcomas in rats. No other studies were found connecting mercury exposure with carcinogenic effects in animals or humans. Several mercury compounds exhibit a variety of genotoxic effects in eukaryotes. In general, organic mercury compounds are more toxic than inorganic compounds. Although brain damage due to prenatal exposure to methylmercury has occurred in human populations, no conclusive evidence is available to suggest that mercury causes anatomical defects in humans. Embryotoxicity and teratogenicity of methylmercury has been reported for a variety of experimental animals. Mercuric chloride is reported to be teratogenic in experimental animals. No conclusive results concerning the teratogenic effects of mercury vapor are available.

In humans, alkyl mercury compounds pass through the blood brain barrier and the placenta very rapidly, in contrast to inorganic mercury compounds. Major target organs are the central and peripheral nervous systems, and the kidney. Methylmercury is particularly hazardous because of the difficulty of eliminating it from the body. In experimental animals, organic mercury compounds can produce toxic effects in the gastrointestinal tract, pancreas, liver, heart, and gonads, with involvement of the endocrine, immunocompetent, and central nervous systems.

Elemental mercury is not highly toxic as an acute poison. However, inhalation of high concentrations of mercury vapor can cause pneumonitis, bronchitis, chest pains, dyspnea, coughing, stomatitis, gingivitis, salivation, and diarrhea. Soluble mercuric salts are highly poisonous on ingestion, with oral LD_{50} values of 20 to 60 mg/kg

reported. Mercurous compounds are less toxic when administered orally. Acute exposure to mercury compounds at high concentrations causes a variety of gastrointestinal symptoms and severe anuria with uremia. Signs and symptoms associated with chronic exposure involve the central nervous system and include behavioral and neurological disturbances.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life (Proposed Criteria)

Freshwater

Acute toxicity: 1.1 ug/liter
Chronic toxicity: 0.20 ug/liter

Saltwater

Acute toxicity: 1.9 ug/liter
Chronic toxicity: 0.10 ug/liter

Human Health

Criterion: 144 ng/liter

Primary Drinking Water Standard: 0.002 mg/liter

NIOSH Recommended Standard: 0.05 mg/m^3) TWA (inorganic mercury)

OSHA Standard: 0.1 mg/m^3) Ceiling Level

ACGIH Threshold Limit Values:

0.01 mg/m^3 TWA (alkyl compounds)
0.03 mg/m^3 STEL (alkyl compounds)
0.05 mg/m^3 TWA (vapor)
0.1 mg/m^3 TWA (aryl and inorganic compounds)

METHYLENE CHLORIDE

Summary

Methylene chloride increased the incidence of lung and liver tumors and sarcomas in rats and mice. It was found to be mutagenic in bacterial test systems. In humans, methylene chloride irritates the eyes, mucous membranes, and skin. Exposure to high levels adversely affects the central and peripheral nervous systems and the heart. In experimental animals, methylene chloride is reported to cause kidney and liver damage, convulsions, and paresis.

CAS Number: 75-09-2

Chemical Formula: CH_2Cl_2

IUPAC Name: Dichloromethane

Important Synonyms and Trade names: Methylene dichloride, methane dichloride

Chemical and Physical Properties

Molecular Weight: 84.93

Boiling Point: 40°C

Melting Point: -95.1°C

Specific Gravity: 1.3266 at 20°C

Solubility in Water: 13,200-20,000 mg/liter at 25°C

Solubility in Organics: Miscible with alcohol and ether

Log Octanol/Water Partition Coefficient: 1.25

Vapor Pressure: 362.4 mm Hg at 20°C

Vapor Density: 2.93

Transport and Fate

Volatilization to the atmosphere appears to be the major mechanism for removal of methylene chloride from aquatic systems and its primary environmental transport process. Photooxidation in the troposphere appears to be the dominant environmental fate of methylene chloride Once in the troposphere, the compound is attacked by

hydroxyl radicals, resulting in the formation of carbon dioxide, and to a lesser extent, carbon monoxide and phosgene. Phosgene is readily hydrolyzed to HCl and CO_2. About one percent of tropospheric methylene chloride would be expected to reach the stratosphere where it would probably undergo photodissociation resulting from interaction with high energy ultraviolet radiation. Aerial transport of methylene chloride is partly responsible for its relatively wide environmental distribution. Atmospheric methylene chloride may be returned to the earth in precipitation.

Photolysis, oxidation, and hydrolysis do not appear to be significant environmental fate processes for methylene chloride, and there is no evidence to suggest that either adsorption or bioaccumulation are important fate processes for this chemical. Although methylene chloride is potentially biodegradable, especially by acclimatized microorganisms, biodegradation probably only occurs at a very slow rate.

Health Effects

Methylene chloride is currently under review by the National Toxicology Program. Preliminary results indicate that it produced an increased incidence of lung and liver tumors in mice and mammary tumors in female and male rats. In a chronic inhalation study, male rats exhibited an increased incidence of sarcomas in the ventral neck region. However, the authors suggested that the relevance and toxicological significance of this finding were uncertain in light of available toxicity data. Methylene chloride is reported to be mutagenic in bacterial test systems. It also has produced positive results in the Fisher rat embryo cell transformation test. However, it has been suggested that the observed cell-transforming capability may have been due to impurities in the test material. There is no conclusive evidence that methylene chloride can produce teratogenic effects.

In humans, direct contact with methylene chloride produces eye, respiratory passage, and skin irritation. Mild poisoning due to inhalation exposure produce somnolence, lassitude, numbness and tingling of the limbs, anorexia, and lightheadedness, followed by rapid and complete recovery. More severe poisoning generally involve correspondingly greater disturbances of the central and peripheral nervous systems. Methylene chloride also has acute toxic effects on the heart, including the induction of arrhythmia. Fatalities reportedly due to methylene chloride exposure have been attributed to cardiac injury and heart failure. Methylene chloride is metabolized to carbon monoxide in vivo, and levels of carboxyhemoglobin in the blood are elevated after acute exposures. In experimental animals, methylene chloride is reported to cause kidney and liver damage, convulsions, and distal paresis. An oral LD_{50} value of 2,136 mg/kg, and an inhalation LC_{50} value of 88,000 mg/m^3/30 min are reported for the rat.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life

The available data are not adequate for establishing criteria.

Human Health

Criterion: 12.4 mg/liter (for protection against the noncarcinogenic effects of methylene chloride)

CAG Unit Risk (U.S. EPA): 1.4×10^{-2} $(mg/kg/day)^{-1}$

NIOSH Recommended Standards:

261 mg/m^3 TWA in the presence of no more than 9.9 mg/m^3 of CO
1,737 mg/m^3/15 min Peak Concentration

OSHA Standard: 1,737 mg/m^3 TWA
3,474 mg/m^3 Ceiling Level
6,948 mg/m^3 Peak Concentration (5 min in any 3 hr)

ACGISH Threshold Limit Value: 350 mg/m^3 TWA
100 ppm TWA
1,740 mg/m^3 STEL
500 ppm STEL

TETRACHLOROETHYLENE

Summary

Tetrachloroethylene (PCE, perchloroethylene) induced liver tumors when administered orally to mice and was found to be mutagenic using a microbial assay system. Reproduction toxicity was observed in pregnant rats and mice exposed to high concentrations. Animals exposed by inhalation to tetrachloroethylene exhibited liver, kidney, and central nervous system damage.

CAS Number: 127-18-4

Chemical Formula: C_2Cl_4

IUPAC Name: Tetrachloroethene

Important Synonyms and Trade Names: Perchloroethylene, PCE

Chemical and Physical Properties

Molecular Weight: 165.83

Boiling Point: 121°C

Melting Point: -22.7°C

Specific Gravity: 1.63

Solubility in Water: 150 to 200 mg/liter at 20°C

Solubility in Organics: Soluble in alcohol, ether, and benzene

Log Octanol/Water Partition Coefficient: 2.88

Vapor Pressure: 14 mm Hg at 20°C

Transport and Fate

Tetrachloroethylene (PCE) rapidly volatilizes into the atmosphere where it reacts with hydroxyl radicals to produce HCl, CO, CO_2, and carboxylic acid. This is probably the most important transport and fate process for tetrachloroethylene in the environment. PCE will leach into the groundwater, especially in soils of low organic content. In soils with high levels of organics, PCE adsorbs to these materials and can be bioaccumulated to some degree. However, it is unclear if tetrachloroethylene bound to organic material can be degraded by microorganisms or must be desorbed to be destroyed. There is some evidence that higher organisms can metabolize PCE.

Health Effects

Tetrachloroethylene was found to produce liver cancer in male and female mice when administered orally by gavage. Unpublished gavage studies in rats and mice performed by the National Toxicology Program (NTP) showed hepatocellular carcinomas in mice and a slight, statistically insignificant increase in a rare type of kidney tumor. NTP is also conducting an inhalation carcinogenicity study. Elevated mutagenic activity was found in Salmonella strains treated with tetrachloroethylene. Delayed ossification of skull bones and sternebrae were reported in offspring of pregnant mice exposed to 2,000 mg/m^3 of tetrachloroethylene for 7 hours/day on days 6-15 of gestation. Increased fetal resorptions were observed after exposure of rats to tetrachloroethylene. Renal toxicity and hepatotoxicity have been noted following chronic inhalation exposure of rats to tetrachloroethylene. Renal toxicity and hepatotoxicity have been noted following chronic inhalation exposure of rats to tetrachloroethylene levels of 1,356 mg/m^3. During the firs 2 weeks of a subchronic inhalation study, exposure to concentrations of 1,6222 ppm (10,867 mg/m^3) of tetrachloroethylene produced signs of central nervous system depression, and chlolinergic stimulation was observed among rabbits, monkeys, rats, and guinea pigs.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life

The available data are not adequate for establishing criteria. However, EPA did report the lowest values known to be toxic in aquatic organisms.

Freshwater

Acute toxicity: 5,280 ug/liter
Chronic toxicity: 840 ug/liter

Saltwater

Acute toxicity: 10,200 ug/liter
Chronic toxicity: 450 ug/liter

Human Health

Estimates of the carcinogenic risks associated with lifetime exposure to various concentrations of tetrachloroethylene in water are:

Risk	Concentration
10^{-5}	8.0 ug/liter
10^{-6}	0.8 ug/liter
10^{-7}	0.08 ug/liter

CAG Unit Risk (U.S. EPA): 5.1×10^{-2} $(mg/kg/day)^{-1}$

NIOSH Recommended Standards (air):

335 mg/m^3 TWA
670 mg/m^3 15-min Ceiling Level

OSHA Standard (air):

670 mg/m^3 TWA
1,340 mg/m^3 Ceiling Level
2,010 mg/m^3 for 5 min every 3 hr, Peak Concentration

ACGIH Threshold Limit Value:

50 ppm TWA
335 mg/m^3 TWA
200 ppm STEL
1,340 mg/m^3 STEL

TOLUENE

Summary

Toluene has been shown to be embryotoxic in experimental animals, and the incidence of cleft palate increased in the offspring of dosed mice. Chronic inhalation exposure to high levels of toluene caused cerebellar degeneration and an irreversible encephalopathy in animals. In humans, acute exposure depressed the central nervous system and caused narcosis.

CAS Number: 108-88-3

Chemical Formula: $C_6H_5CH_3$

IUPAC Name: Methylbenzene

Important Synonyms and Trade Names: Toluol, phenylmethane

Chemical and Physical Properties

Molecular Weight: 92.13

Boiling Point: 110.6°C

Melting Point: -95°C

Specific Gravity: 0.8669 at 20°C

Solubility in Water: 534.8 mg/liter

Solubility in Organics: Soluble in acetone, ligroin, and carbon disulfide; miscible with alcohol, ether, benzene, chloroform, glacial acetic acid, and other organic solvents

Log Octanol/Water Partition Coefficient: 2.69

Vapor Pressure: 28.7 mm Hg at 25°C

Vapor Density: 3.14

Flash Point: 4.4°C

Transport and Fate

Volatilization appears to be the major route of removal of toluene from aquatic environments, and atmospheric reactions of toluene probably subordinate all other fate processes. Photooxidation is the primary atmospheric fate process for toluene, and benzaldehyde is reported to be the principal organic product. Subsequent precipitation or dry deposition can deposit toluene and its oxidation products into aquatic and terrestrial systems. Direct photolytic cleavage of toluene is energetically improbable in the troposphere, and oxidation and hydrolysis are probably not important as aquatic fates.

The log octanol/water partition coefficient of toluene indicates that sorption processes may be significant. However, no specific environmental sorption studies are available, and the extent to which adsorption by sedimentary and suspended organic material may interfere with volatilization is unknown. Bioaccumulation is probably not an important environmental fate process. Although toluene is known to be degraded by microorganisms and can be detoxified and excreted by mammals, the available data do not allow estimation of the relative importance of biodegradation/biotransformation processes. Almost all toluene discharged to the environment by industry is in the form of atmospheric emissions.

Health Effects

There is no conclusive evidence that toluene is carcinogenic or mutagenic in animals or humans. The National Toxicological Program is currently conducting an inhalation carcinogenicity bioassay in rats and mice.

Oral administration of toluene at doses as low as 260 mg/kg produced a significant increase in embryonic lethality in mice. Decreased fetal weight was observed at doses as low as 434 mg/kg, and an increased incidence of cleft palate was seen at doses as low as 867 mg/kg. However, other researches have reported that toluene is embryotoxic but not teratogenic in laboratory animals. There are no accounts of a teratogenic effect in humans after exposure to toluene.

Acute exposure to toluene at concentrations of 375-1,500 mg/kg produces central nervous system depression and narcosis in humans. However, even exposure to quantities sufficient to produce unconsciousness fail to produce residual organ damage. The rat oral LD_{50} value and inhalation LC_{LO} value are 5,000 mg/kg and 15,000 mg/m^3, respectively. Chronic inhalation exposure to toluene at relatively high concentrations produces cerebellar degeneration and an irreversible encephalopat in mammals.

Toluene in sufficient amounts appears to have the potential to alter significantly the metabolism and resulting bioactivity of certain chemicals. For example, coadministration of toluene along with benzene or styrene has been shown to suppress the metabolism of benzene or styrene in rats.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life

The available data are not adequate for establishing criteria. However, EPA did report the lowest values known to cause toxicity in aquatic organisms.

Freshwater

Acute toxicity: 17,500 ug/liter
Chronic toxicity: No available data

Saltwater

Acute toxicity: 6,300 ug/liter
Chronic toxicity: 5,000 ug/liter

Human Health

Criterion: 14.3 mg/liter

NIOSH Recommended Standards: 375 mg/m^3 TWA
560 mg/m^3 STEL

OSHA Standards: 750 mg/m^3 TWA
1,120 mg/m^3 Ceiling Level

ACGIH Threshold Limit Value: 100 ppm TWA
375 mg/m^3 TWA
150 ppm STEL
560 mg/m^3 STEL

1,1,1-TRICHLOROETHANE

Summary

Preliminary results suggest that 1,1,1-trichloroethane (1,1,1-TCA) induces liver tumors in female mice. It was shown to be mutagenic using the Ames assay, and it causes transformation in cultured rat embryo cells. Inhalation exposure to high concentrations of 1,1,1-TCA depressed the central nervous system; affected cardiovascular function; and damaged the lungs, liver, and kidneys in animals and humans. Irritation of the skin and mucous membranes has also been associated with human exposure to 1,1,1-trichloroethane.

CAS Number: 71-55-6

Chemical Formula: CH_3CCl_3

IUPAC Name: 1,1,1-Trichloroethane

Important Synonyms and Trade Names: Methyl chloroform, chlorothene, 1,1,1-TCA

Chemical and Physical Properties

Molecular Weight: 133.4

Boiling Point: 74.1°C

Melting Point: -30.4°C

Specific Gravity: 1.34 at 20°C (liquid)

Solubility in Water: 480-4,400 mg/liter at 20°C (several divergent values were reported in the literature)

Solubility in Organics: Soluble in acetone, benzene, carbon tetrachloride, methanol, ether, alcohol, and chlorinated solvents

Log Octanol/Water Partition Coefficient: 2.17

Vapor Pressure: 123 mm Hg at 20°C

Vapor Density: 4.63

Transport and Fate

1,1,1-Trichloroethane (1,1,1-TCA) disperses from surface water primarily by volatilization. Several studies have indicated that 1,1,1-trichloroethane may be adsorbed onto organic materials in the sediment, but this is probably not an important route of elimination from surface water. 1,1,1-Trichloroethane can be transported in the groundwater, but the speed of transport depends on the composition of the soil.

Photooxidation by reaction with hydroxyl radicals in the atmosphere is probably the principal fate process for this chemical.

Health Effects

1,1,1-Trichloroethane was retested for carcinogenicity because in a previous study by NCI, early lethality precluded assessment of carcinogenicity. Preliminary results indicate that 1,1,1-TCA increased the incidence of combined hepatocellular carcinomas and adenomas in female mice when administered by gavage. There is evidence that 1,1,1-trichloroethane is mutagenic in Salmonella typhimurium and causes transformation in cultured rat embryo cells. These data suggest that the chemical may be carcinogenic.

Other effects of 1,1,1-TCA are seen only at concentrations well above those likely in an open environment. The most notable toxic effects of 1,1,1-trichloroethane in humans and animals are central nervous system depression, including anesthesia at very high concentrations and impairment of coordination, equilibrium, and judgment at lower concentrations (350 ppm and above); cardiovascular effects, including premature ventricular contractions, decreased blood pressure, and sensitization to epinephrine-induced arrhythmia; and adverse effects on the lungs, liver, and kidneys. Irritation of the skin and mucous membranes resulting from exposure to 1,1,1-trichloroethane has also been reported. The oral LD_{50} value of 1,1,1-trichloroethane in rats is about 11,000 mg/kg.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life

The available data are not adequate for establishing criteria. However, EPA did report, the lowest values of the two trichloroethanes (1,1,1 and 1,1,2) known to be toxic in aquatic organisms.

Freshwater

Acute toxicity: 18 mg/liter
Chronic toxicity: 8.4 mg/liter

Saltwater

Acute toxicity: 31.2 mg/liter
Chronic toxicity: No available data

Human Health

Criterion: 18.4 mg/liter

NIOSH Recommended Standard: 350 ppm (1,910 mg/m^3)/15 min Ceiling Level

OSHA Standard: 350 ppm (1,910 mg/m^3) TWA

ACGIH Threshold Limit Value: 350 ppm TWA
1,400 mg/m^3 TWA
450 ppm STEL
2,450 mg/m^3 STEL.

1,1,2-TRICHLOROETHANE

Summary

1,1,2-Trichloroethane induced liver tumors and pheochromocytomas in mice. It caused liver and kidney damage in dogs.

CAS Number: 79-00-5

Chemical Formula: $CH_2ClCHCl_2$

IUPAC Name: 1,1,2-Trichloroethane

Important Synonyms and Trade Names: Vinyl trichloride, ethane trichloride

Chemical and Physical Properties

Molecular Weight: 133.41

Boiling Point: 133.8°C

Melting Point: -36.5°C

Specific Gravity: 1.4397 at 25°C

Solubility in Water: 4,500 mg/liter at 20°C

Solubility in Organics: Soluble in alcohol, ether, and chloroform

Log Octanol/Water Partition Coefficient: 2.17

Vapor Pressure: 19 mm Hg at 20°C

Vapor Density: 4.63

Transport and Fate

Volatilization and subsequent photooxidation in the troposphere are probably the primary transport and fate processes for 1,1,2-trichloroethane. Some sorption, bioaccumulation, and biodegradation may occur, but these processes are probably not very important processes for trichloroethane transport or fate.

1,1,2-Trichloroethane induced heptacellular carcinomas and pheochromocytoma of the adrenal gland in male and female mice but did not produce a significant increase in tumor incidence in male or female rats. It was not mutagenic when tested using the Ames assay. No information was found concerning the reproductive toxicity or

teratogenicity of 1,1,2-trichloroethane. No chronic studies were found on the toxicity of 1,1,2-trichloroethane but single doses as low as 400 mg/kg caused liver and kidney damage in dogs. The oral LD_{50} value for 1,1,2-trichloroethane in rats is 835 mg/kg.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life

The available data are not sufficient for establishing criteria. However, EPA did report the lowest values known to be toxic in aquatic organisms.

Freshwater

Acute toxicity: 18,000 ug/liter
Chronic toxicity: 9,400 ug/liter

Saltwater

Acute toxicity: No available data
Chronic toxicity: No available data

Human Health

Estimates of the carcinogenic risks associated with lifetime exposure to various concentrations of 1,1,2-trichloroethane in water are:

Risk	Concentration
10^{-5}	6.0 ug/liter
10^{-6}	0.6 ug/liter
10^{-7}	0.06 ug/liter

CAG Unit Risk (U.S. EPA): 5.7×10^{-2} $(mg/kg/day)^{-1}$

ACGIH Threshold Limit Value: 10 ppm TWA (skin)
45 mg/m^3 TWA (skin)

TRICHLOROETHYLENE

Summary

Trichloroethylene (TCE) induced hepatocellular carcinomas in mice and was mutagenic when tested using several microbial assay systems. Chronic inhalation exposure to high concentrations caused liver, kidney, and neural damage and dermatological reactions in animals.

CAS Number: 79-01-06

Chemical Formula: C_2HCl_3

IUPAC Name: Trichloroethene

Important Synonyms and Trade Names: Trichloroethene, TCE, and ethylene trichloride

Chemical and Physical Properties

Molecular Weight: 131.5

Boiling Point: 87°C

Melting Point: -73°C

Specific Gravity: 1.4642 at 20°C

Solubility in Water: 1,000 mg/liter

Solubility in Organics: Soluble in alcohol, ether, acetone, and chloroform

Log Octanol/Water Partition Coefficient: 2.29

Vapor Pressure: 60 mm Hg at 20°C

Vapor Density: 4.53

Transport and Fate

Trichloroethylene (TCE) rapidly volatilizes into the atmosphere where it reacts with hydroxyl radicals to produce hydrochloric acid, carbon monoxide, carbon dioxide, and carboxylic acid. This is probably the most important transport and fate process for trichloroethylene in surface water and in the upper layer of soil. TCE adsorbs to organic materials and can be bioaccumulated to some degree. However, it is unclear whether trichloroethylene bound to organic materiaL can be degraded by

microorganisms or must be desorbed to be destroyed. There is some evidence that higher organisms can metabolize TCE. Trichloroethylene leaches into the groundwater fairly readily, and it is a common contaminant of groundwater around hazardous waste sites.

Health Effects

Trichloroethylene is carcinogenic to mice after oral administration, producing hepatocellular carcinomas. It was found to be mutagenic using several microbial assay systems. Trichloroethylene does not appear to cause reproductive toxicity or teratogenicity. TCE has been shown to cause renal toxicity, hepatotoxicity, neurotoxicity, and dermatological reactions in animals following chronic exposure to levels greater than 2,000 mg/m^3 for 6 months. Trichloroethylene has low acute toxicity; the acute oral LD_{50} value in several species ranged from 6,000 to 7,000 mg/kg.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life

The available data are not adequate for establishing criteria. However, EPA did report the lowest values known to have toxic effects in aquatic organisms.

Freshwater

Acute toxicity: 45 mg/liter
Chronic toxicity: No available data

Saltwater

Acute toxicity: 2 mg/liter
Chronic toxicity: No available data

Human Health

Estimates of the carcinogenic risks associated with lifetime exposure to various concentrations of trichloroethylene in water are:

Risk	Concentration
10^{-5}	27 ug/liter
10^{-6}	2.7 ug/liter
10^{-7}	0.27 ug/liter

CAG Unit Risk (U.S. EPA): 1.1×10^{-2} $(mg/kg/day)^{-1}$

NIOSH Recommended Standards (air):
540 mg/m^3 TWA
760 mg/m^3 10-min Ceiling Level

OSHA Standard (skin): 540 mg/m^3 TWA
1,075 mg/m^3/15-min Ceiling Level
1,620 mg/m^3 for 5 min every 3 hr, Peak Concentration

ACGIH Threshold Limit Values: 50 ppm TWA
270 mg/m^3 TWA
200 ppm STEL
1,080 mg/m^3 STEL

XYLENES

Summary

Xylene has been shown to be fetotoxic in rats and mice. In humans, exposure to high concentrations of xylene adversely affects the central nervous system and irritates the mucous membranes.

Background Information

Xylene has three isomers, o-, m-, and p-xylene. These three generally have similar chemical and biological characteristics and therefore will be discussed together.

CAS Number:
- Mixed: 1330-20-7
- m-Xylene: 108-38-3
- o-Xylene: 95-47-6
- p-Xylene: 106-42-3

Chemical Formula: $C_6H_4(CH_3)_2$

IUPAC Name: Dimethylbenzene

Important Synonyms and Trade Names:
- Mixed xylene: Dimethylbenzene, xylol
- m-Xylene: 1,3-Dimethylbenzene, m-xylol
- o-Xylene: 1,2-Dimethylbenzene, o-xylol
- p-Xylene: 1,4-Dimethylbenzene, p-xylol

Chemical and Physical Properties

Molecular Weight: 106.17

Boiling Point:
- Mixed: 137-140°C
- m-Xylene: 139°C
- o-Xylene: 144°C
- p-Xylene: 138°C

Melting Point:
- m-Xylene: -48°C
- o-Xylene: -25°C
- p-Xylene: 13°C

Specific Gravity: 0.86

Solubility in Water: 160 mg/liter at 25°C

Solubility in Organics: Soluble in alcohol, ether, and other organic solvents.

Log Octanol/Water Partition Coefficient: 3

Vapor Pressure: 10 mm Hg at 25°C

Vapor Density: 3.7

Flash Point: 25°C (closed cup)

Transport and Fate

Volatilization and subsequent photooxidation by reaction with hydroxyl radicals in the atmosphere are probably important transport and fate processes for xylene in the upper layer of soil and in aquatic environments. Products of the hydroxylation reaction include carbon dioxide, peroxyacetylnitrate (PAN), and cresol. Xylene binds to sediment in water and to organics in soils and undergoes microbial degradation. Biodegradation is probably the most important fate process in both soils and the aquatic environment. Xylenes have been shown to persist for up to 6 months in soil. Because of their low water solubility and rapid biodegradation, xylenes are unlikely to leach into groundwater in high concentrations.

Health Effects

The National Toxicology Program (NTP) is testing xylene for carcinogenicity by administering it orally to rats and mice. Although the results have not been finalized, it does not appear to be carcinogenic in rats. Results have not been reported for mice. Xylene was not found to be mutagenic in a battery of short-term assays. Xylene is not teratogenic but has caused fetotoxicity in rats and mice. Acute exposure to rather high levels of xylene affects the central nervous system and irritates the mucous membranes. There is limited evidence of effects on other organ systems, but it was not possible to attribute these effects solely to xylene as other solvents were present. The oral LD_{50} value of xylene in rats is 5,000 mg/kg.

Regulations and Standards

NIOSH Recommended Standard (air):

435 mg/m^3 TWA
870 mg/m^3 10-min Ceiling Level

OSHA Standard: 435 mg/m^3 TWA

ACGIH Threshold Limit Values:

100 ppm TWA
435 mg/m^3 TWA
150 ppm STEL
655 mg/m^3 STEL

ZINC

Summary

Ingestion of excessive amounts of zinc can cause fever, vomiting, and stomach cramps. Zinc oxide fumes can cause metal fume fever. Inhalation of mists or fumes may irritate the respiratory tract, and contact with zinc chloride may irritate the eyes and skin. High levels of zinc in the diet have been shown to retard growth and produce defective mineralization of bone.

Background Information

Zinc generally exists in nature as a salt with a valence of +2, although it is also found in four other stable valences.

CAS Number: 7440-66-6

Chemical Formula: Zn

IUPAC Name: Zinc

Chemical and Physical Properties

Atomic Weight: 65.38

Boiling Point: 907°C

Melting Point: 419.58°C

Specific Gravity: 7.133 at 25°C

Solubility in Water: Insoluble; some salts are soluble

Solubility in Organics: Soluble in acid and alkali

Vapor Pressure: 1 mm Hg at 487°C

Transport and Fate

Zinc can occur in both suspended and dissolved forms. Dissolved zinc may occur as the free (hydrated) zinc ion or as dissolved complexes and compounds with varying degrees of stability and toxicity. Suspended (undissolved) zinc may be dissolved following minor changes in water chemistry or may be sorbed to suspended matter. The predominant fate of zinc in aerobic aquatic systems is sorption of the divalent cation by hydrous iron and manganese oxides, clay minerals, and organic material. The efficiency of these materials in removing zinc from solution varies according to their compositions and concentrations; the pH and salinity of the water; the

concentrations of complexing ligands; and the concentration of zinc. Concentrations of zinc in suspended and bed sediments always exceed concentrations in ambient water. In reducing environments, precipitation of zinc sulfide limits the mobility of zinc. However, under aerobic conditions, precipitation of zinc compounds is probably important only where zinc is present in high concentrations. Zinc tends to be more readily sorbed at higher pH than lower pH and tends to be desorbed from sediments as salinity increases. Compounds of zinc with the common ligands of surface waters are soluble in most neutral and acidic solutions, so that zinc is readily transported in most unpolluted, relatively organic-free waters.

The relative mobility of zinc in soil is determined by the same factors affecting its transport in aquatic systems. Atmospheric transport of zinc is also possible. However, except near sources such as smelters, zinc concentrations in air are relatively low and fairly constant.

Since it is an essential nutrient, zinc is strongly bioaccumulated even in the absence of abnormally high ambient concentrations. Zinc does not appear to be biomagnified. Although zinc is actively bioaccumulated in aquatic systems, the biota appear to represent a relatively minor sink compared to the sediments. Zinc is one of the most important metals in biological systems. Since it is actively bioaccumulated, the environmental concentrations of zinc probably exhibit seasonal fluctuations.

Health Effects

Testicular tumors have been produced in rats and chickens when zinc salts are injected intratesticularly, but not when other routes of administration are used. Zinc may be indirectly important with regard to cancer since its presence seems to be necessary for the growth of tumors. Laboratory studies suggest that although zinc-deficient animals may be more susceptible to chemical induction of cancer, tumor growth is slower in these animals. There is no evidence that zinc deficiency has any etiological role in human cancer. There are no data available to suggest that zinc is mutagenic or teratogenic in animals or humans.

Zinc is an essential trace element that is involved in enzyme functions, protein synthesis, and carbohydrate metabolism. Ingestion of excessive amounts of zinc may cause fever, vomiting, stomach craps, and diarrhea. Fumes of freshly formed zinc oxide can penetrate deep into the alveoli and cause metal fume fever. Zinc oxide dust does not produce this disorder. Contact with zinc chloride can cause skin and eye irritation. Inhalation of mists or fumes may irritate the respiratory and gastrointestinal tracts. Zinc in excess of 0.25% in the diet of rats causes growth retardation, hypochromic anemia, and defective mineralization of bone. No zinc toxicity is observed at dietary levels below 0.25%.

Studies with animals and humans indicate that metabolic changes may occur due to the interaction of zinc and other metals in the diet. Exposure to cadmium can cause changes in the distribution of zinc, with increases in the liver and kidneys, organs where cadmium also accumulates. Excessive intake of zinc may cause copper

deficiencies and result in anemia. Interaction of zinc with iron or lead may also lead to changes that are not produced when the metals are ingested individually.

Regulations and Standards

Ambient Water Quality Criteria (U.S. EPA):

Aquatic Life

Freshwater

Acute toxicity: $e^{\{0.83[\ln(\text{hardness})] + 1.95\}}$ ug/liter
Chronic toxicity: 47 ug/liter

Saltwater

Acute toxicity: 170 ug/liter
Chronic toxicity: 58 ug/liter

Human Health

Organoleptic criterion: 5 mg/liter

Secondary Drinking Water Standard: 5 mg/liter

NIOSH Recommended Standard: 5 mg/m^3 (zinc oxide)

OSHA Standard: 5 mg/m^3 TWA (zinc oxide)

ACGIH Threshold Limit Values:

Zinc chloride fume:	1 mg/m^3 TWA
	2 mg/m^3 STEL
Zinc oxide fume:	5 mg/m^3 TWA
	10 mg/m^3 STEL
Zinc oxide dust:	10 mg/m^3 TWA (nuisance particulate)
Zinc stearate:	10 mg/m^3 TWA (nuisance particulate)
	20 mg/m^3 STEL